

PERFORMANCE MEASURES FOR TRAFFIC SIGNAL MAINTENANCE

Jay Grossman, Elkhart County Highway Department

Outline:

- **Background and Motivation**
- Pedestrian Calls
 - Operational Verification
 - Methodology
 - Call Button Error Detection
- Vehicle Detector Analysis
 - Methodology
 - Case Studies
 - Conclusions

Maintenance Performance Measures

Developed on two local agency systems in Indiana

Mishawaka

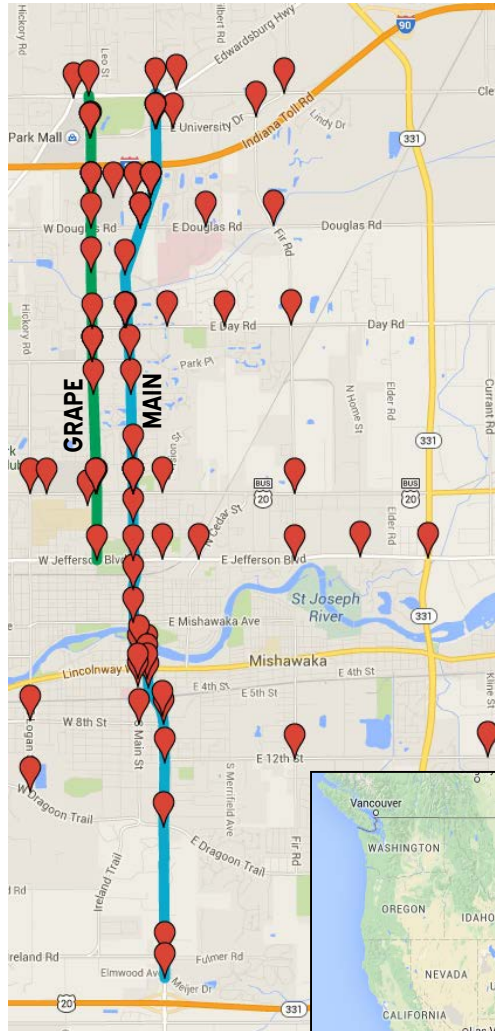
64 signals

37 reporting

22 with peds

1181 detection channels

6.6 M records per day



Elkhart County

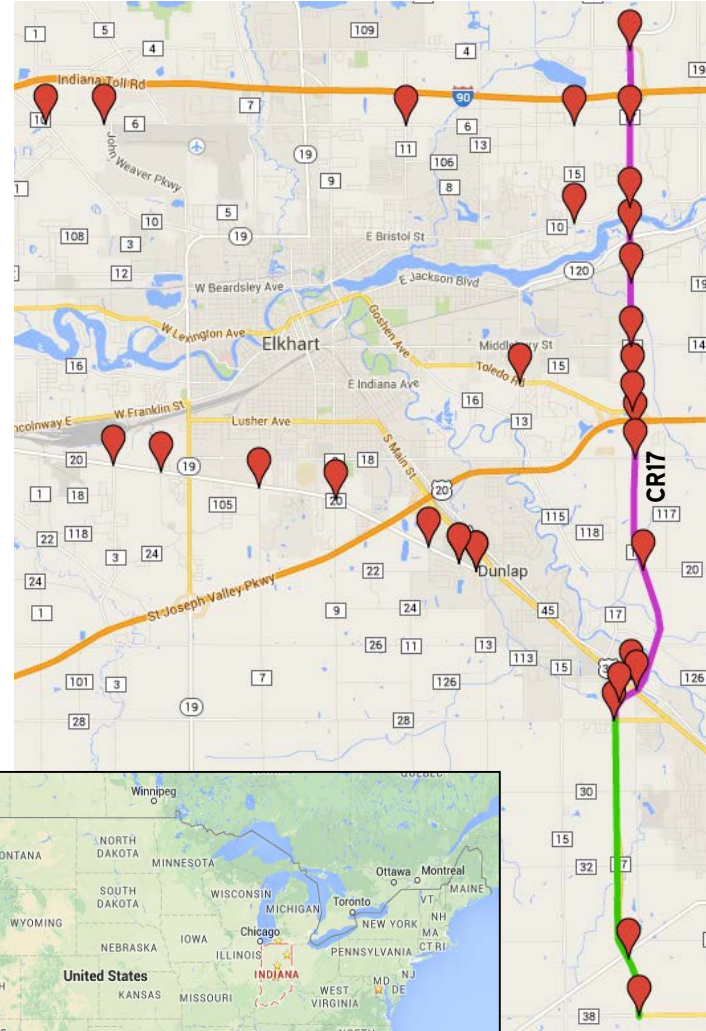
29 signals

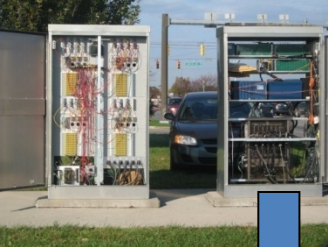
21 reporting

3 with peds

671 detection channels

2.7 M records per day





2003

Original Performance Measure Evolution



2006

ftp://128.46.170.250/set1/ - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Search Folders

Address ftp://128.46.170.250/set1/

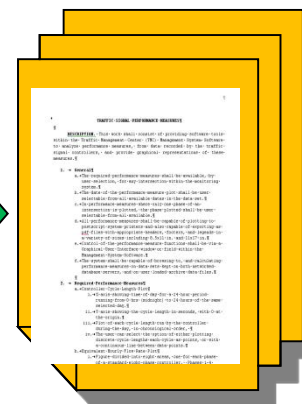
Name	Size	Type
ASC3.DB	109 KB	Data Base File
asc3app	2.12 MB	File
asc3Screens.defs	98.1 KB	DEFS File
asc3Screens.help	298 KB	HELP File
asc3Screens.text	39.3 KB	TEXT File
INT_0001_2006_07_25_0800.dat	53.0 KB	DAT File
INT_0001_2006_07_25_0900.dat	50.8 KB	DAT File
INT_0001_2006_07_25_1000.dat	50.1 KB	DAT File
INT_0001_2006_07_25_1100.dat	56.3 KB	DAT File
INT_0001_2006_07_25_1200.dat	57.5 KB	DAT File
INT_0001_2006_07_25_1300.dat	60.3 KB	DAT File
INT_0001_2006_07_25_1400.dat	63.7 KB	DAT File
INT_0001_2006_07_25_1500.dat	72.6 KB	DAT File



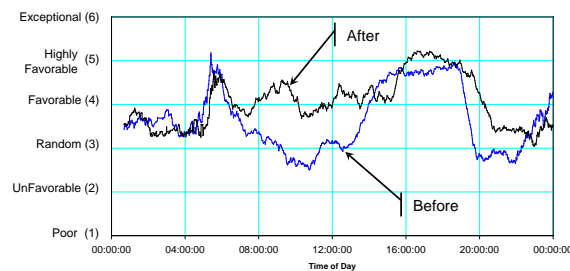
2011

Central System

Procurement Specification



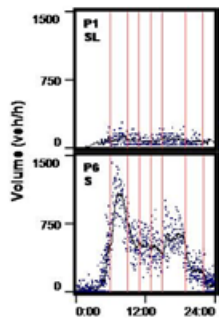
2010



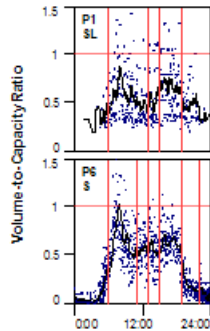
2008

Performance Measures Converted to Specifications

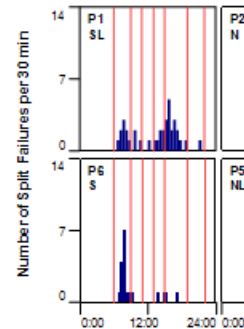
Equivalent Hourly Flow Rate



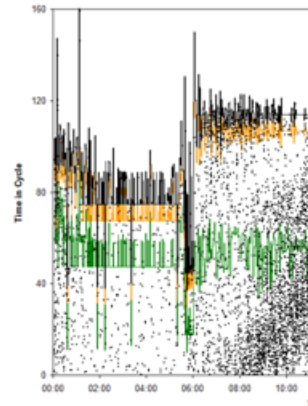
Volume to Capacity Ratio



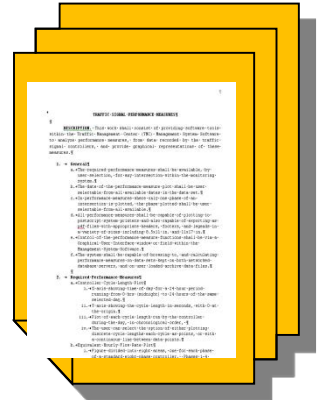
Split Failures Per Half Hour



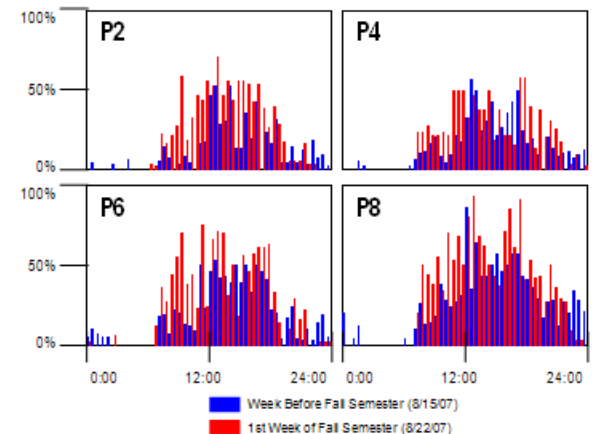
Purdue Coordination Diagram (PCD)



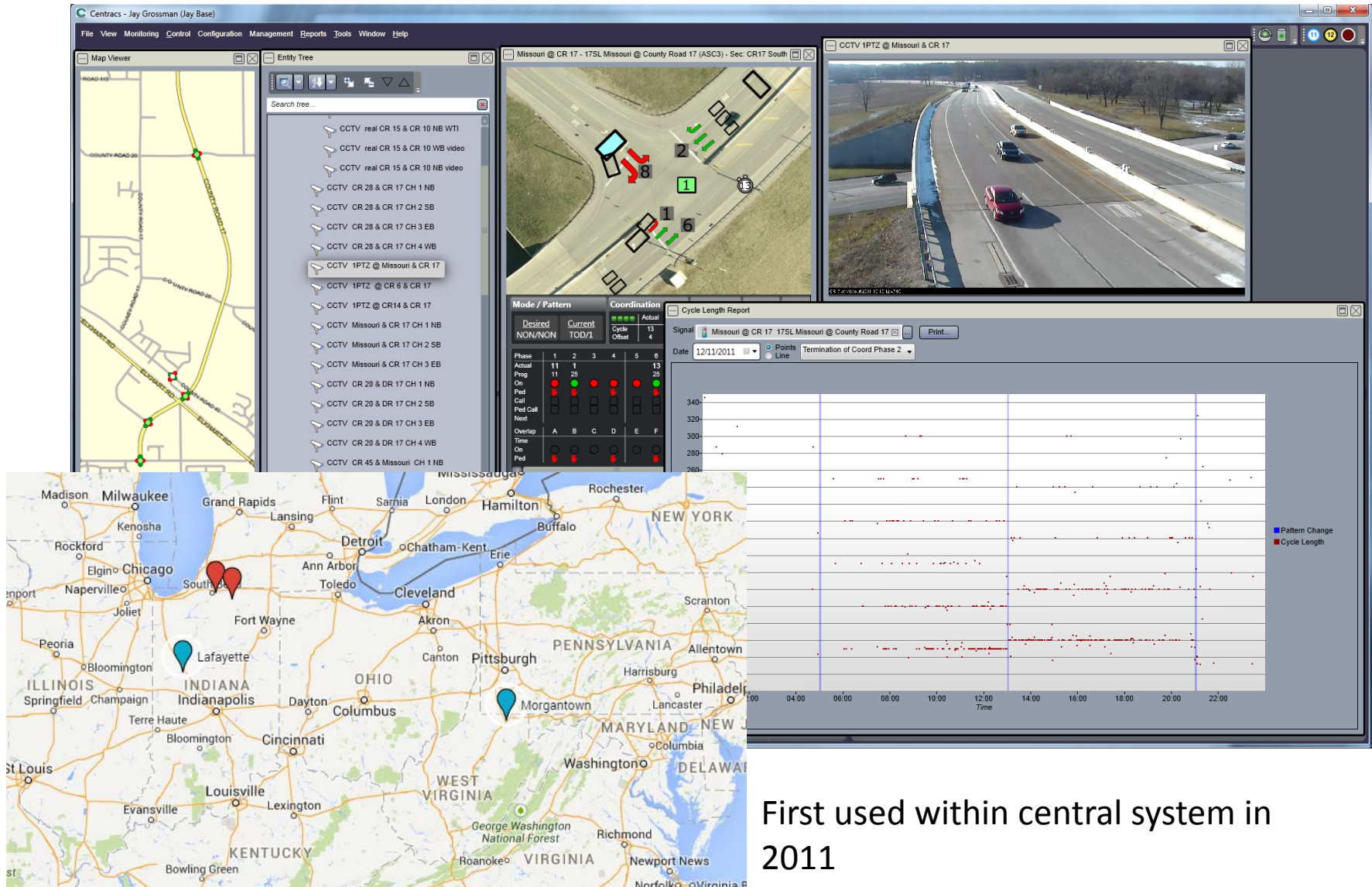
Procurement Specification



Percentage of Phases with Peds



Reports generated within central system



First used within central system in 2011

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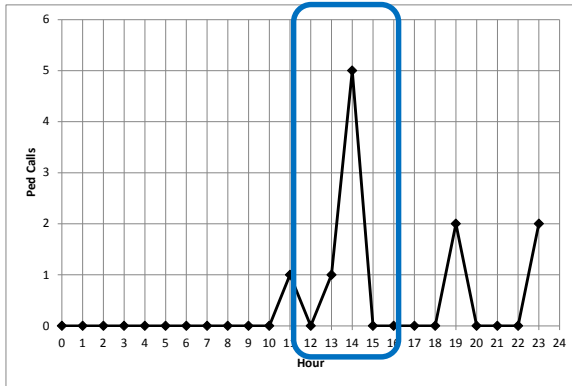


Pedestrian Calls

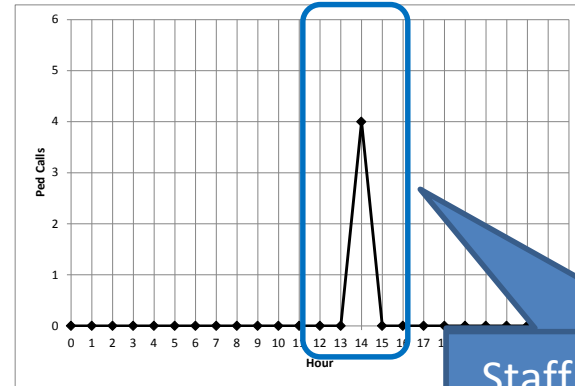
Operational Verification

Some phases are rarely activated. Still working?

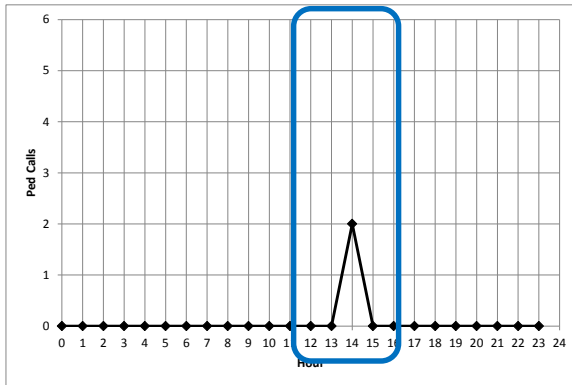
$\phi 2$



$\phi 4$



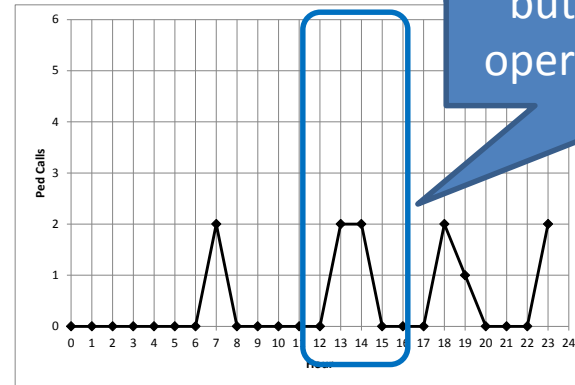
Activations



Hour of Day

$\phi 6$

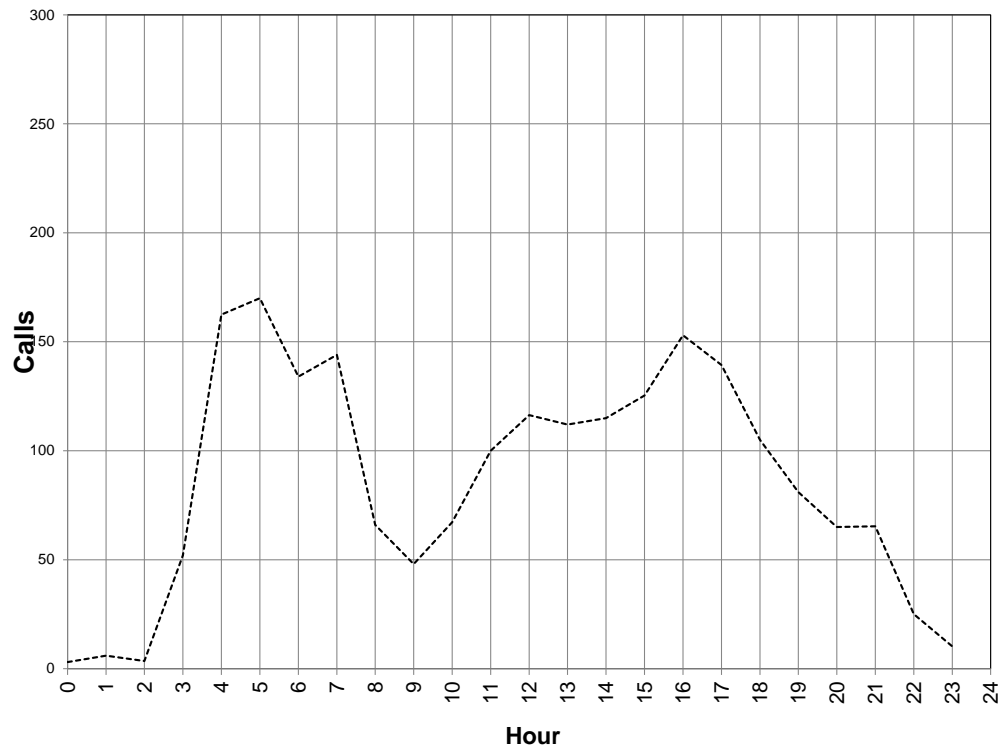
$\phi 8$



Staff activated each call button, logs used for operational verification

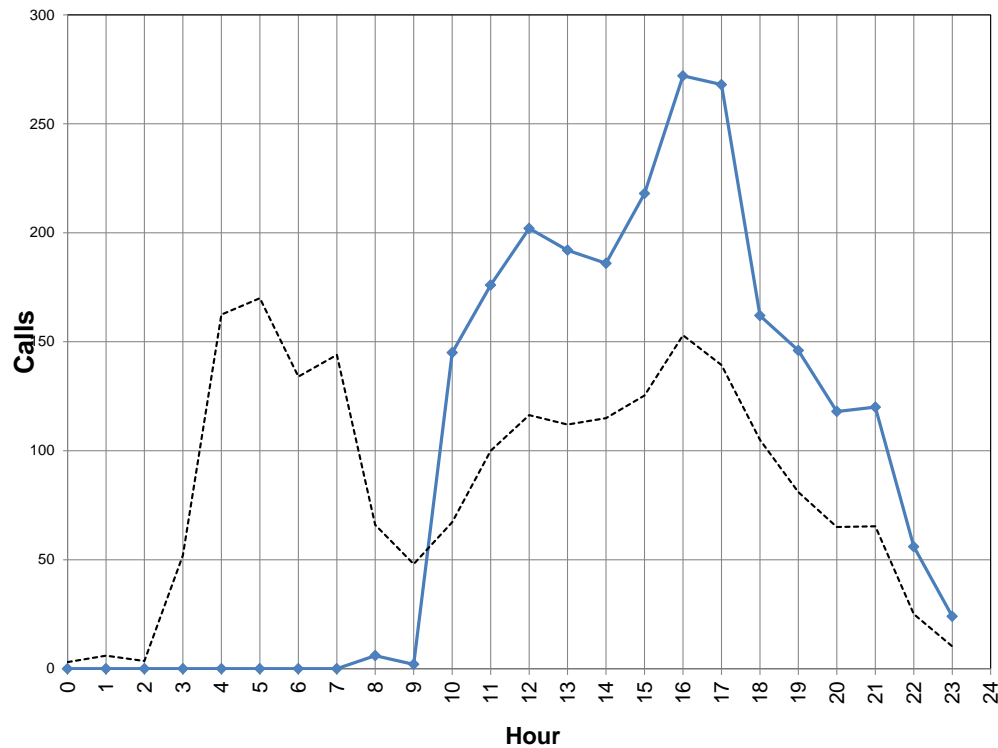
Methodology:

- **Use Historic Data for a sensor channel to develop base lines of 'normal' behavior**
- Plot current period activity
- Identify potential errors



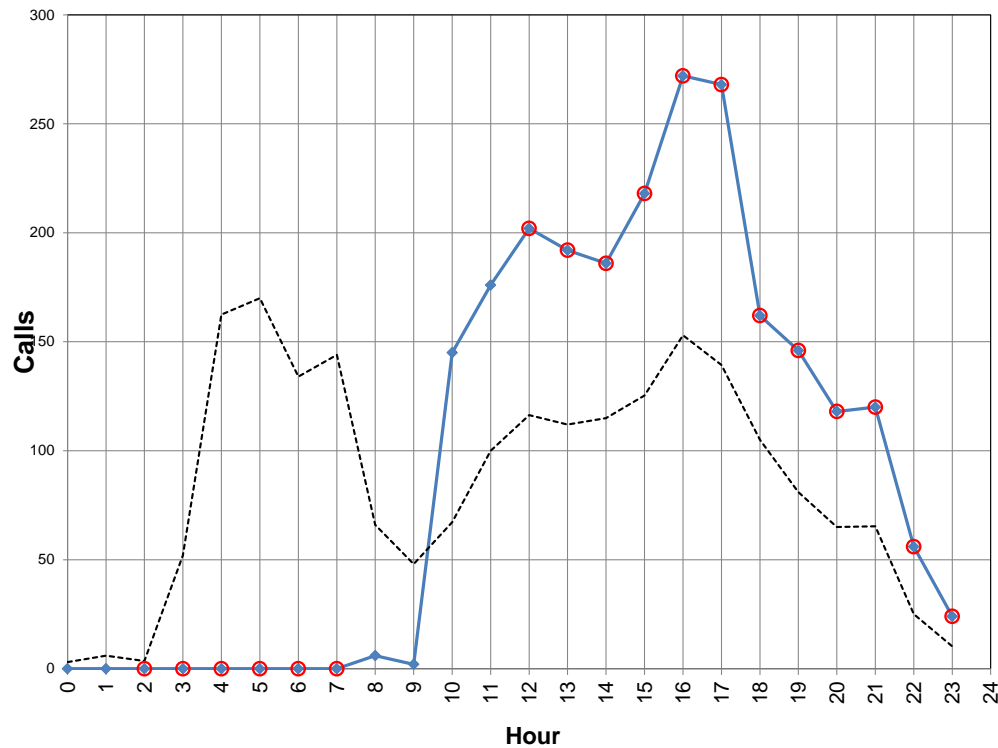
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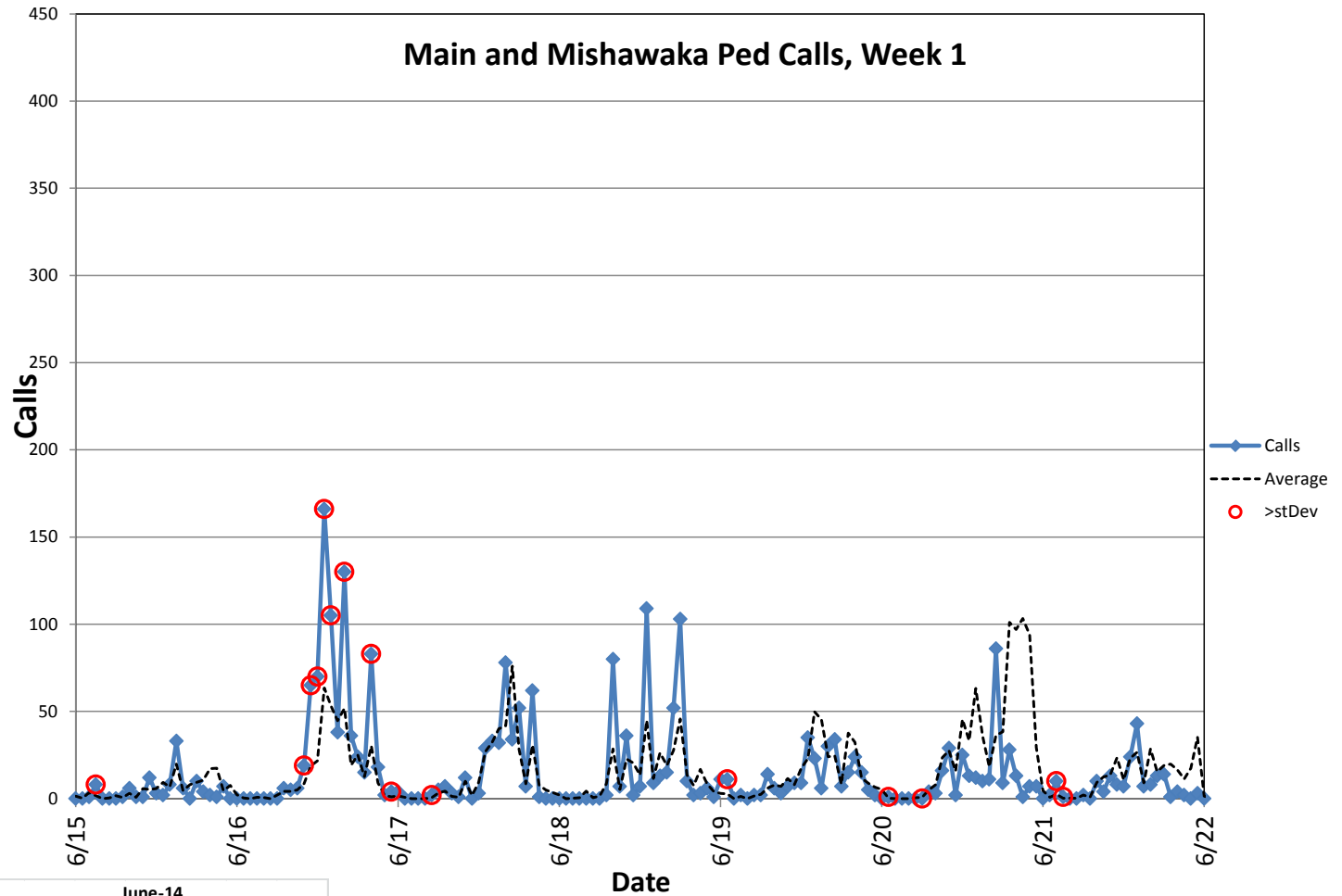
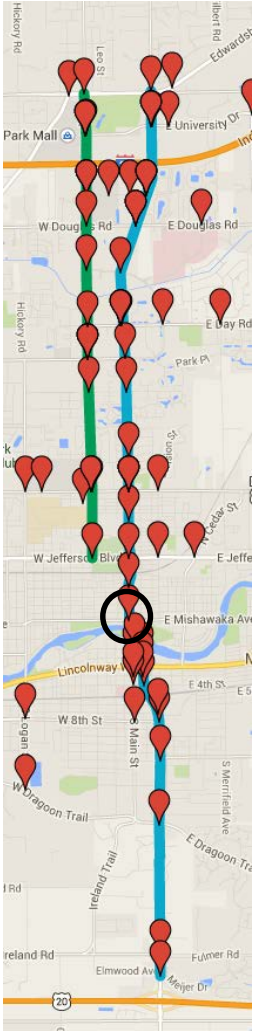


Methodology:

- Use Historic Data for a sensor channel to develop base lines of 'normal' behavior
- Plot current period activity
- **Identify potential errors**

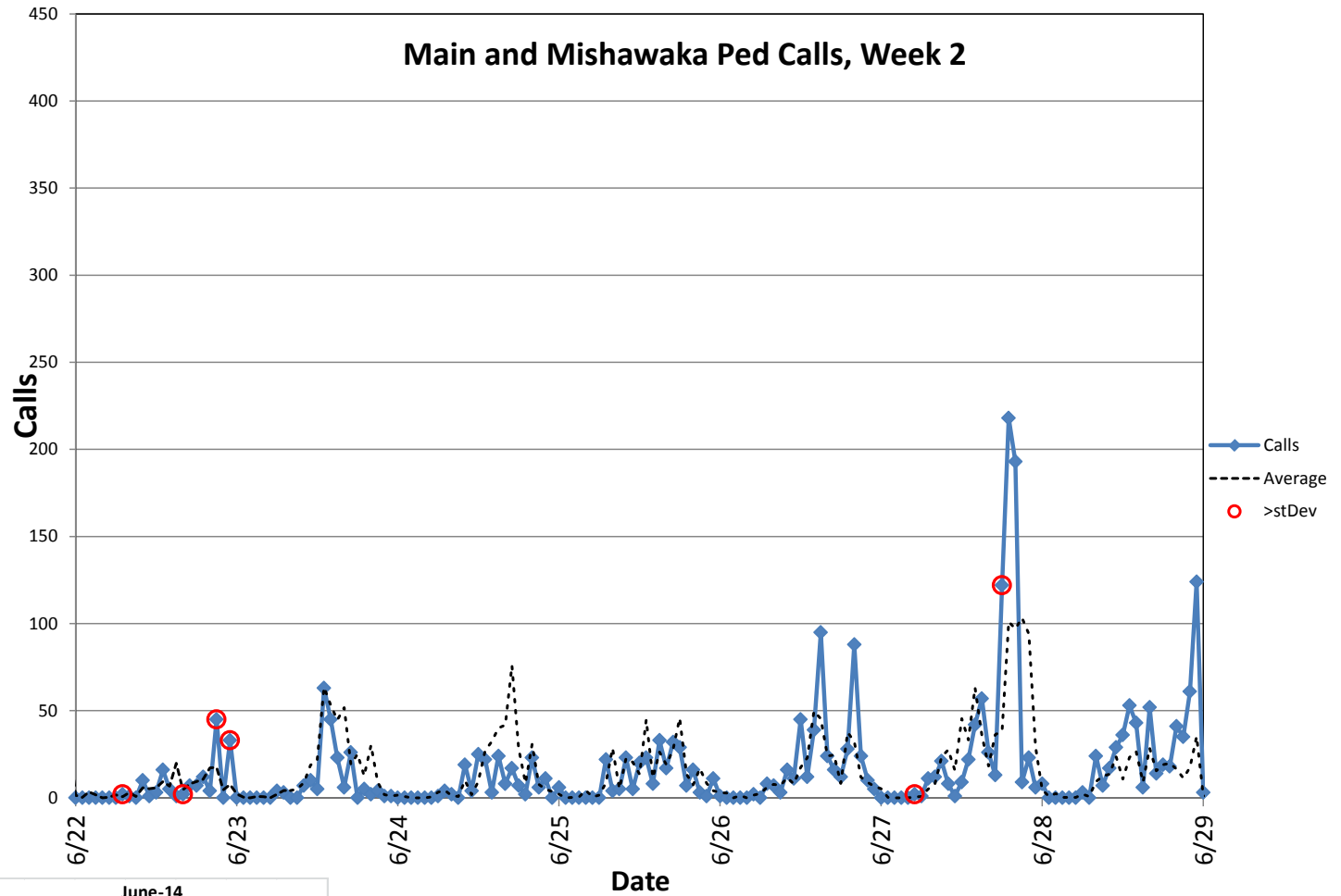
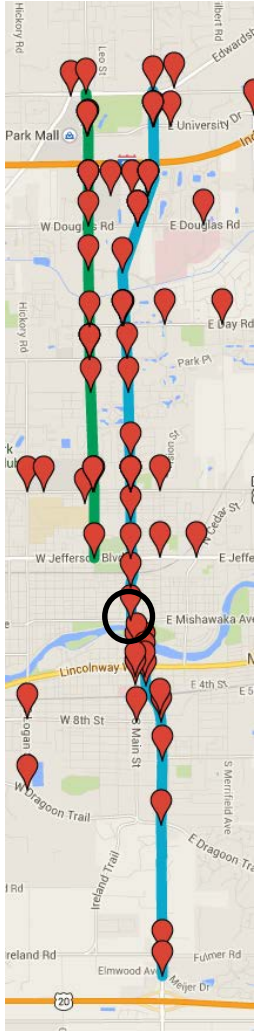


Mishawaka: pedestrian call analysis



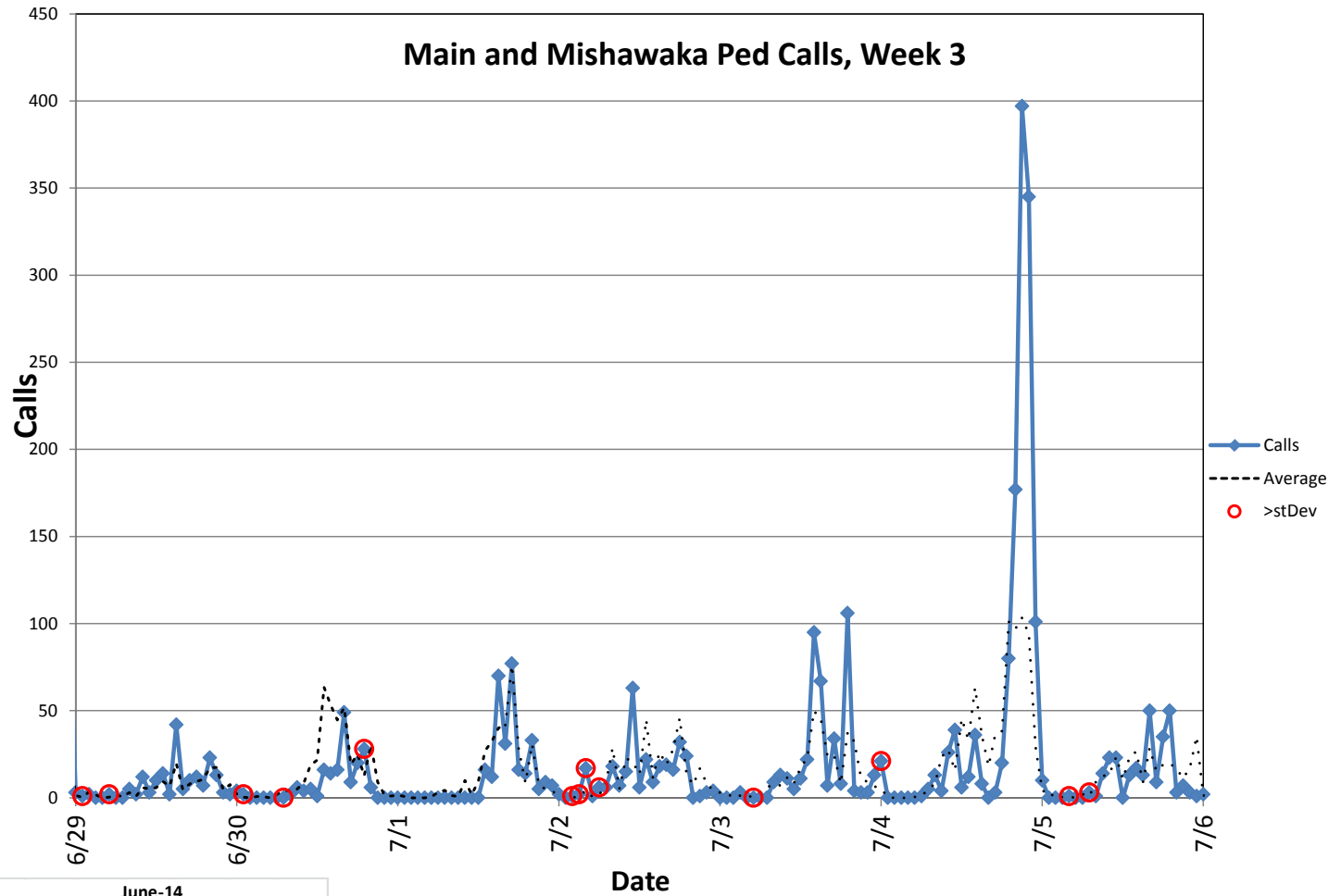
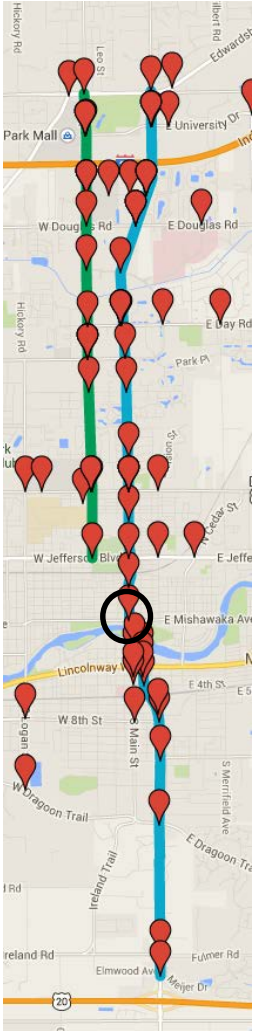
June-14						
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

Mishawaka: pedestrian call analysis



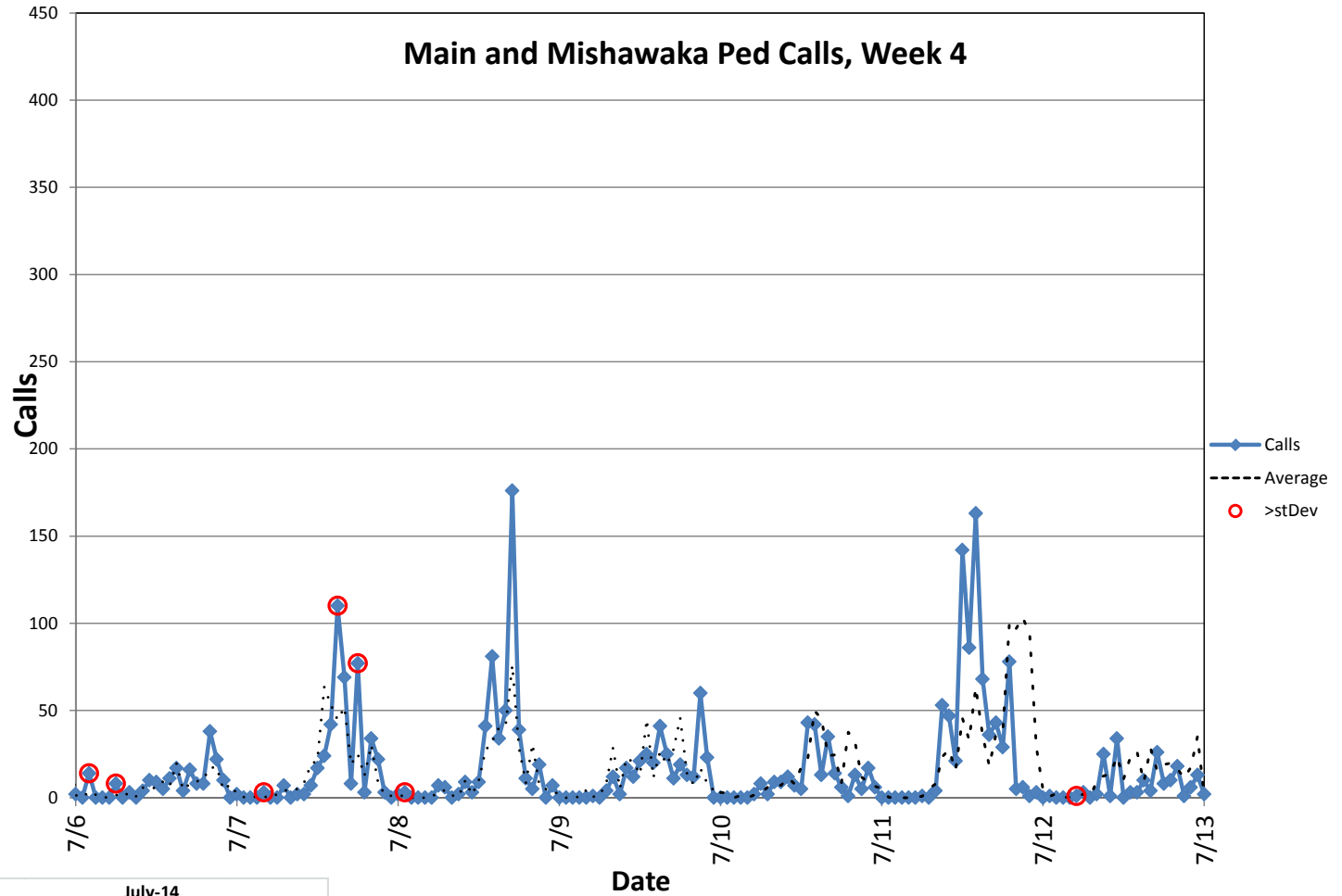
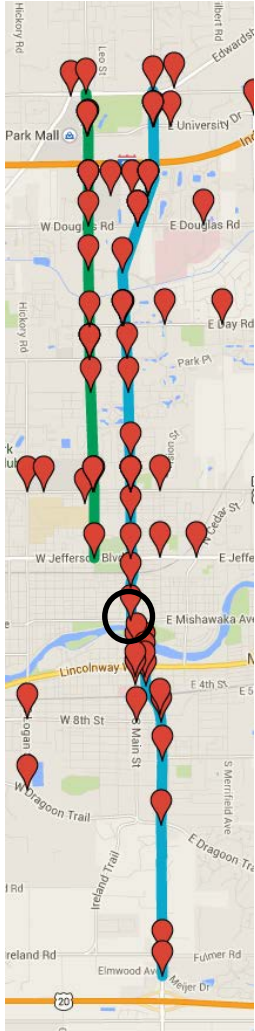
June-14						
S	M	T	W	T	F	S
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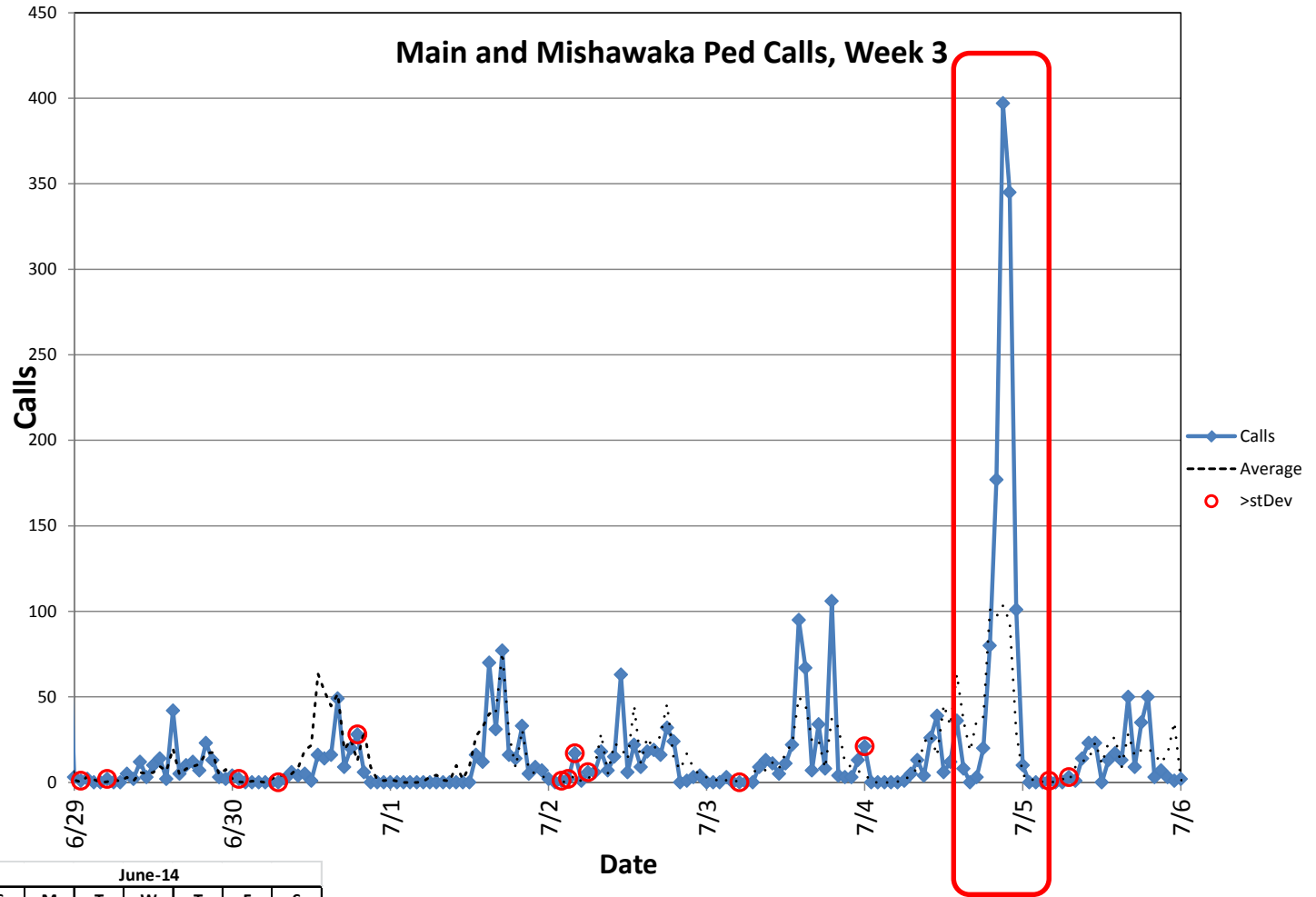
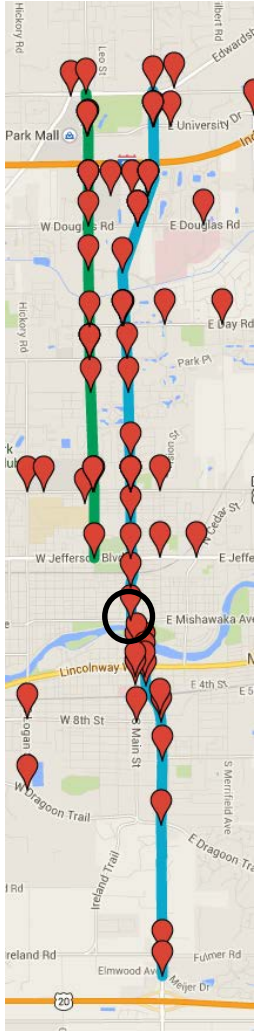
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29	30	1	2	3	4	5

Mishawaka: pedestrian call analysis



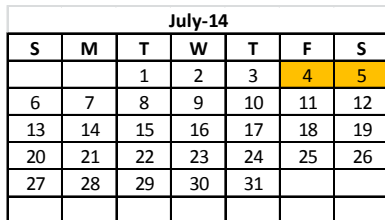
July-14						
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6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Mishawaka: pedestrian call analysis

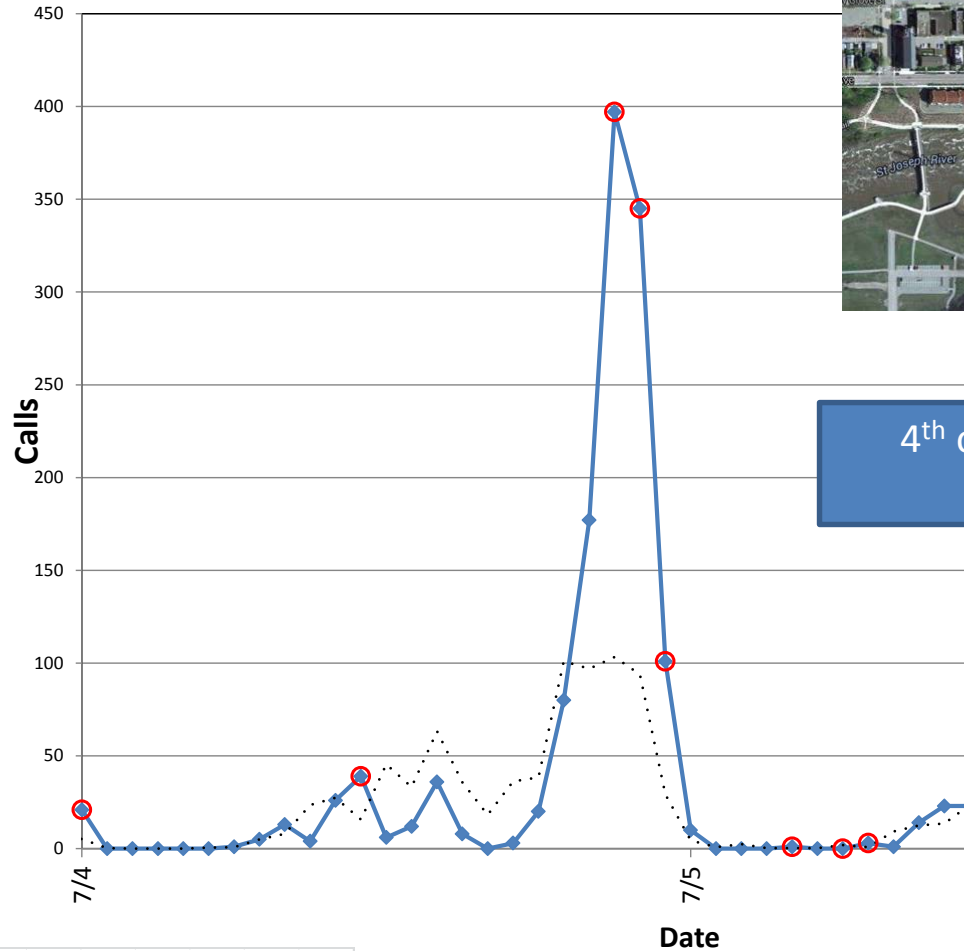
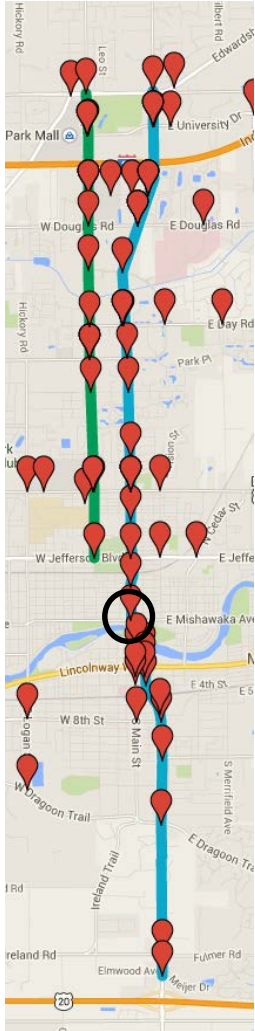


June-14						
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5

A map of the Lincolnway area in Lincoln, Nebraska. The map shows a grid of streets including Park Mall, University Dr, W Douglas Rd, E Douglas Rd, E Gay Rd, W Jefferson Blvd, E Jefferson Blvd, E Mishawaka Ave, E 4th St, E 5th St, W 8th St, Main St, W Dragon Trail, Ireland Trail, E Dragon Trail, Ireland Rd, Elmwood Ave, and Fulmer Rd. A blue line runs vertically through the center of the map, and a green line runs vertically to its left. Numerous red pins are placed along these lines and other streets. A black circle highlights a red pin located at the intersection of Lincolnway and Main St.



Mishawaka: pedestrian call analysis



July-14						
S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
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Outline:

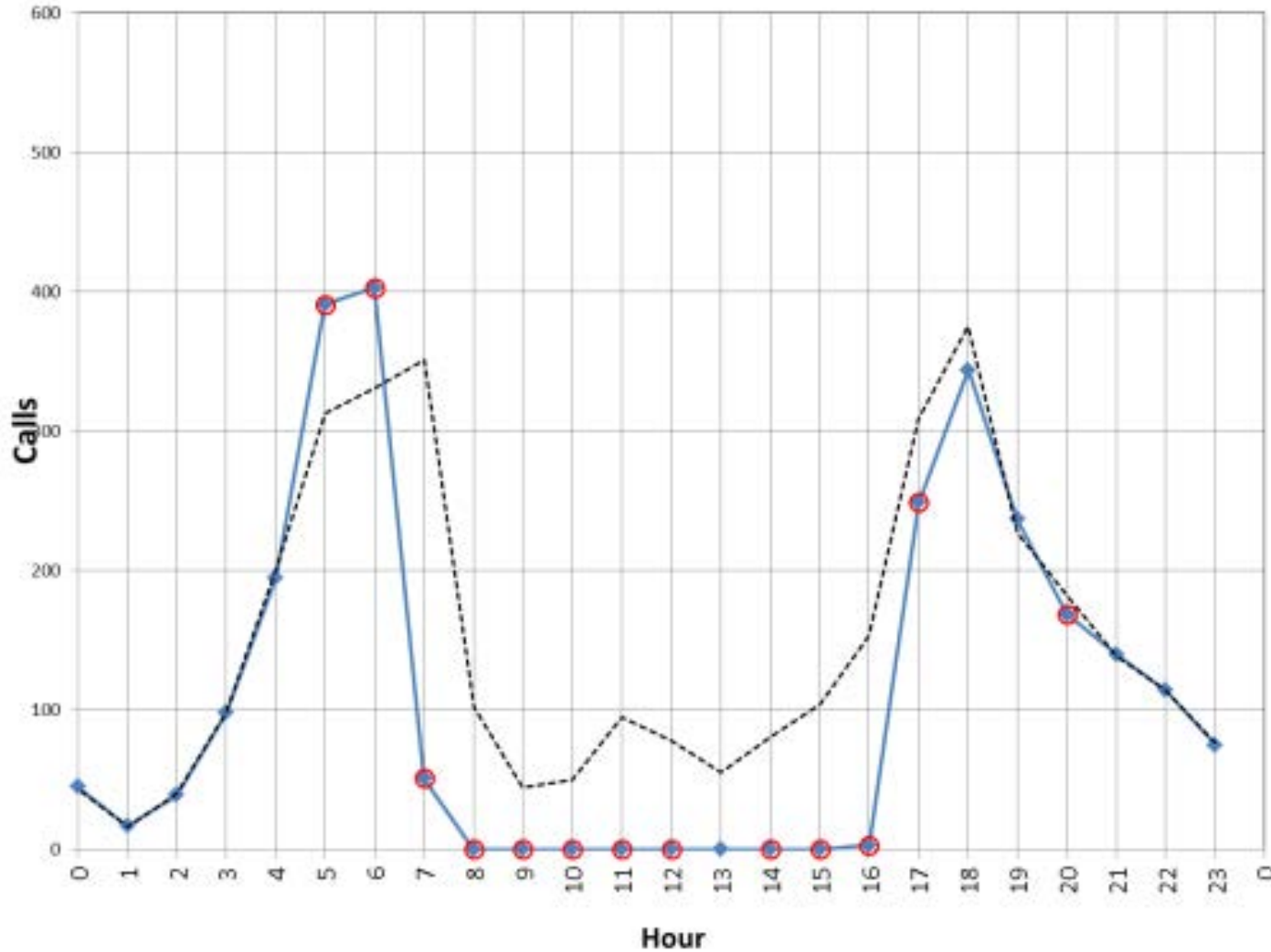
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Vehicle Detector Analysis

Methodology: Base Line

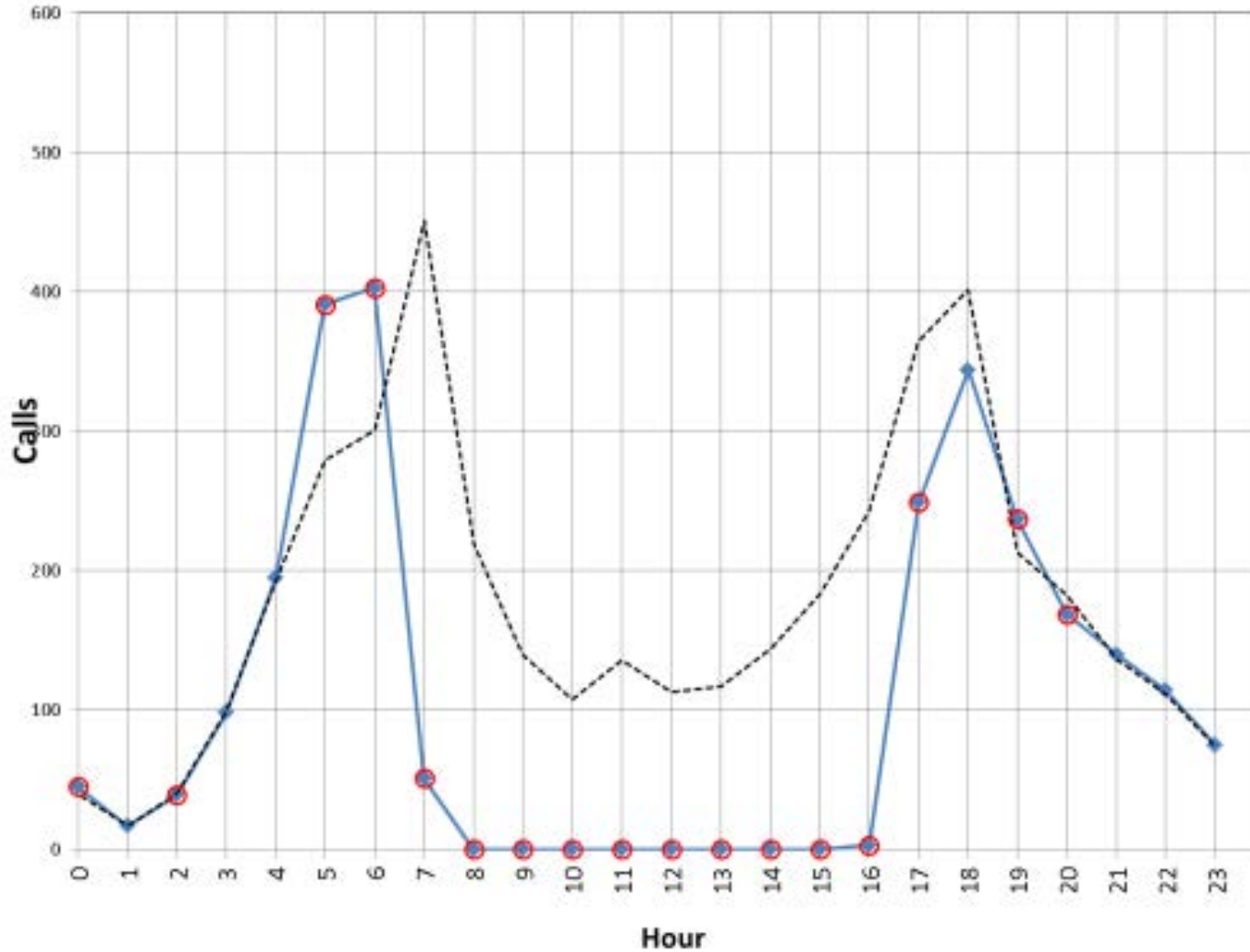
1 Week of Data



Vehicle Detector Analysis

Methodology: Base Line

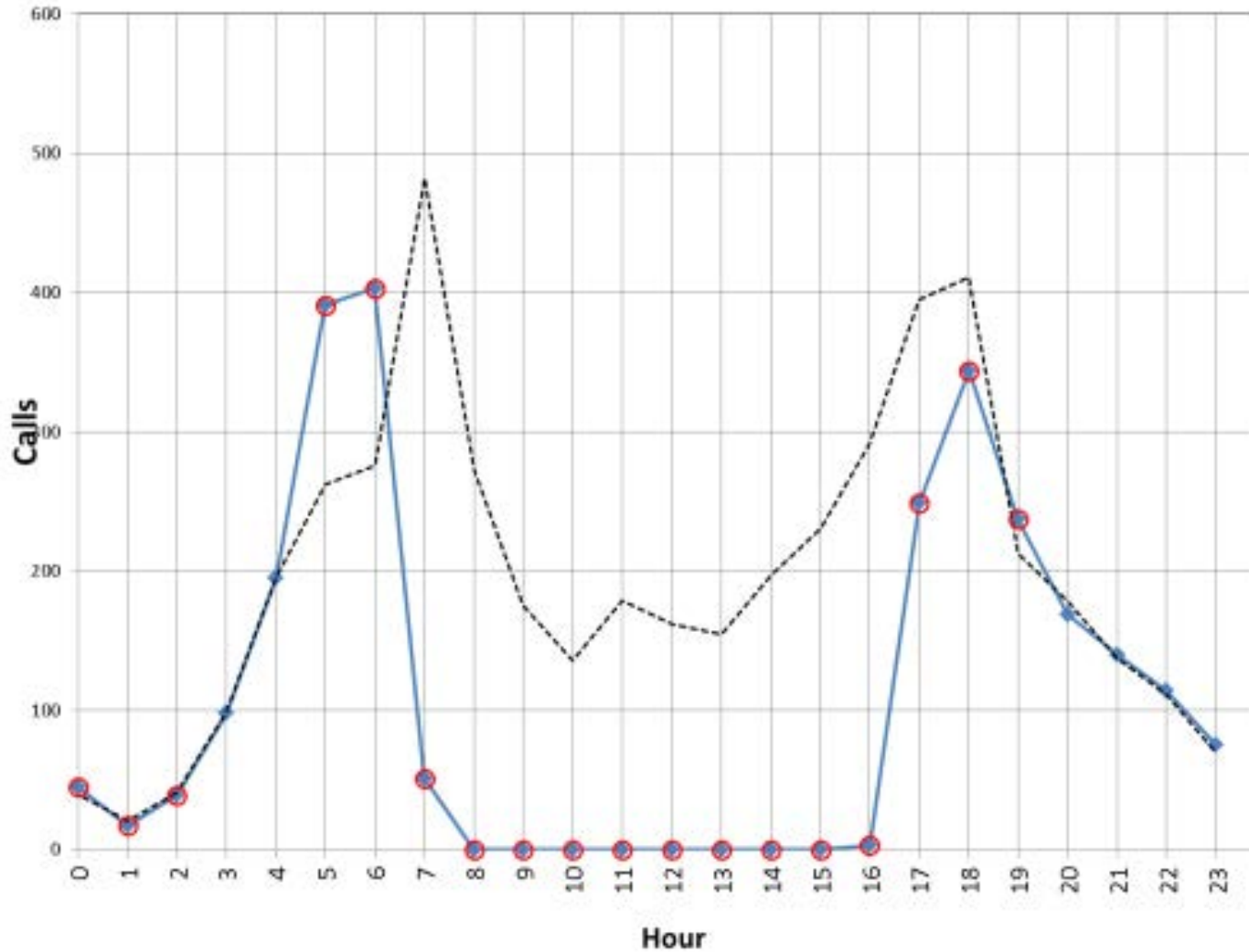
2 Weeks of Data



Vehicle Detector Analysis

Methodology: Base Line

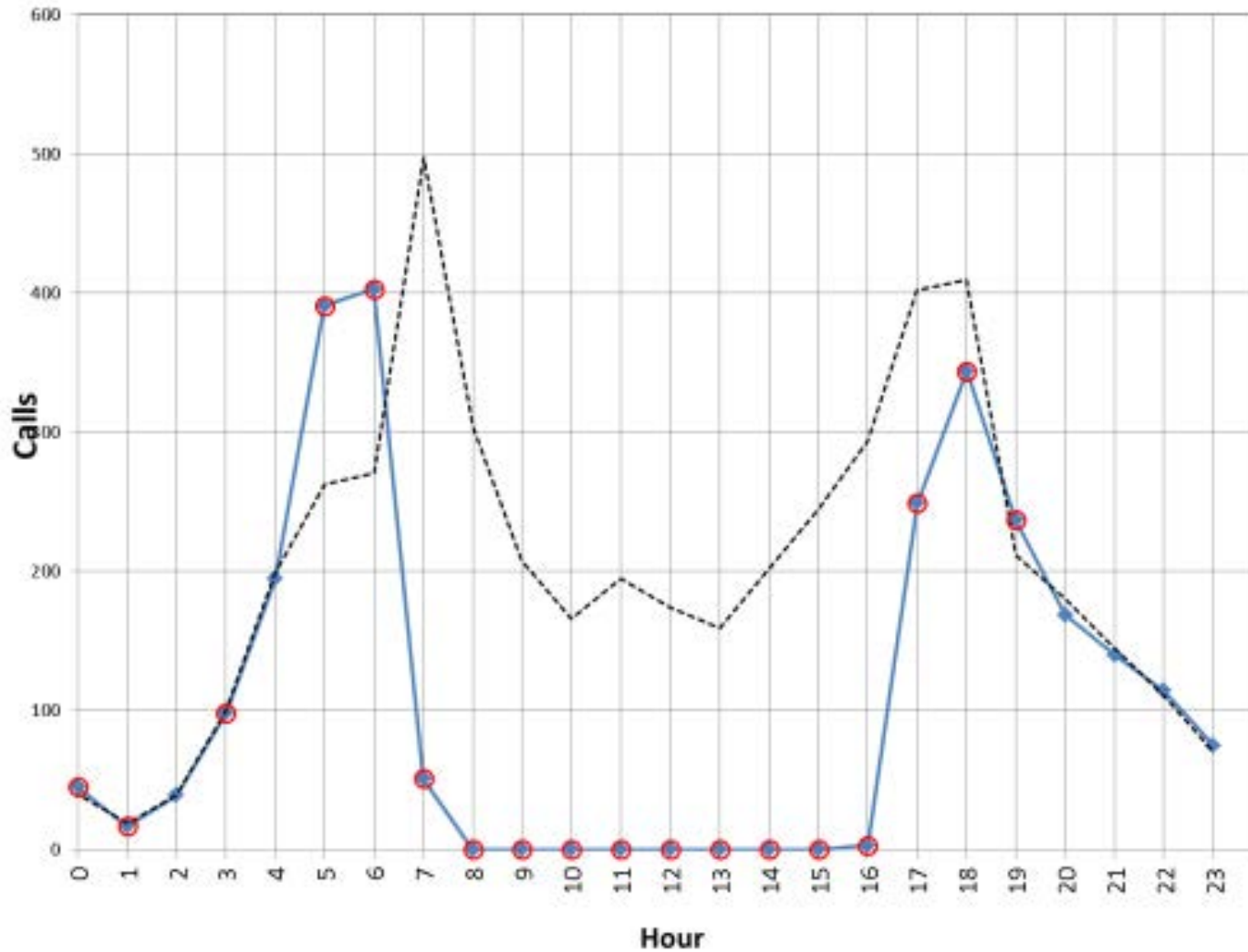
3 Weeks of Data



Vehicle Detector Analysis

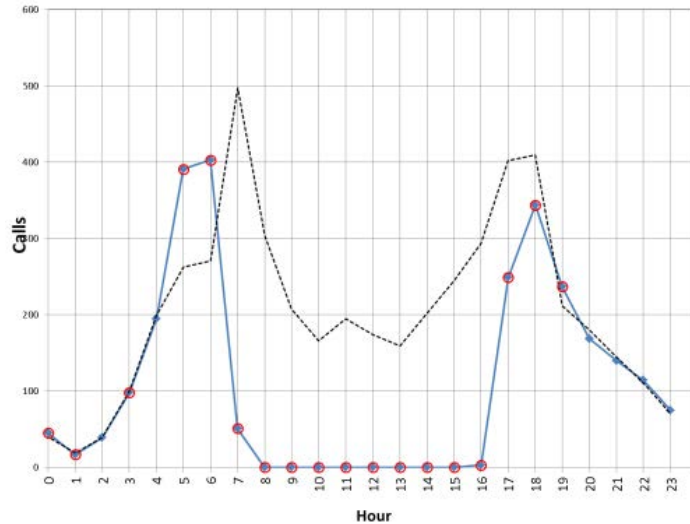
Methodology: Base Line

4 Weeks of Data



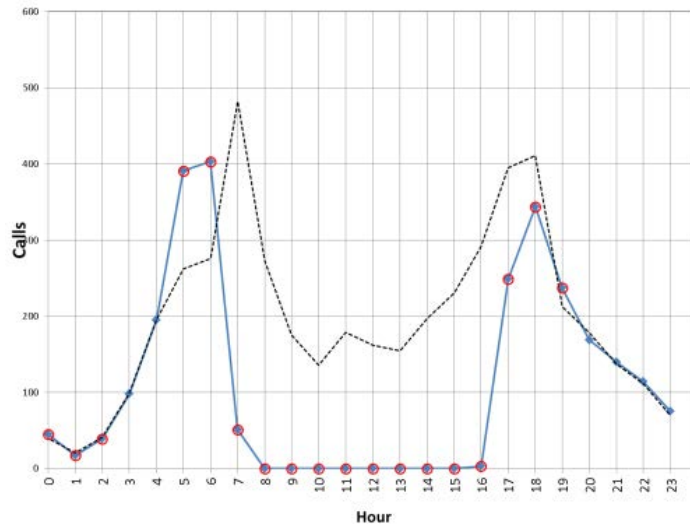
Vehicle Detector Analysis

Methodology: Base Line



3 Weeks of Data

Three weeks of data for base line creation has worked best in our analysis. Four weeks adds little extra detail for error identification



4 Weeks of Data

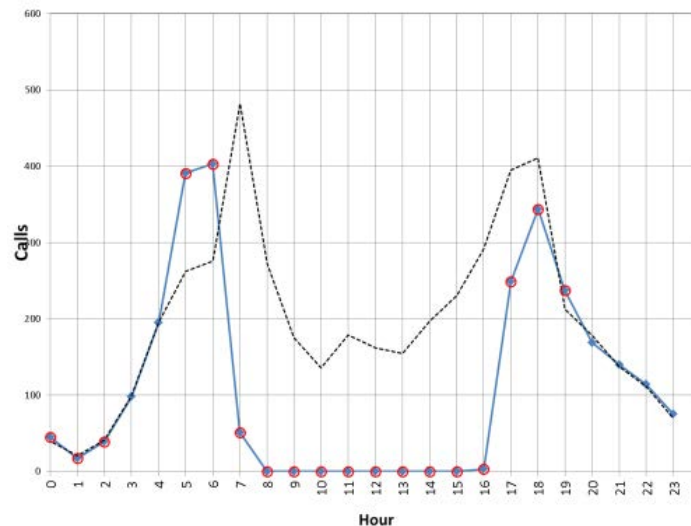
Computationally, entire system of more than 1100 detection channels can be analyzed in less than 5 minutes

Vehicle Detector Analysis

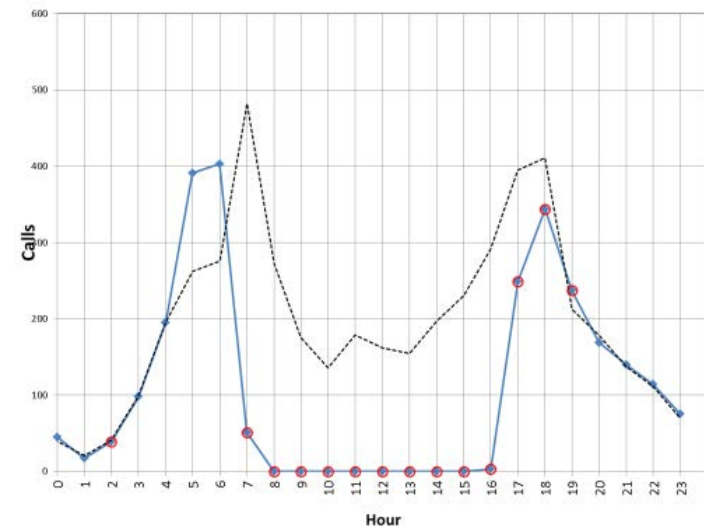
Methodology: Error Threshold

Minimize false error alerts

Standard Deviation ≥ 1.5

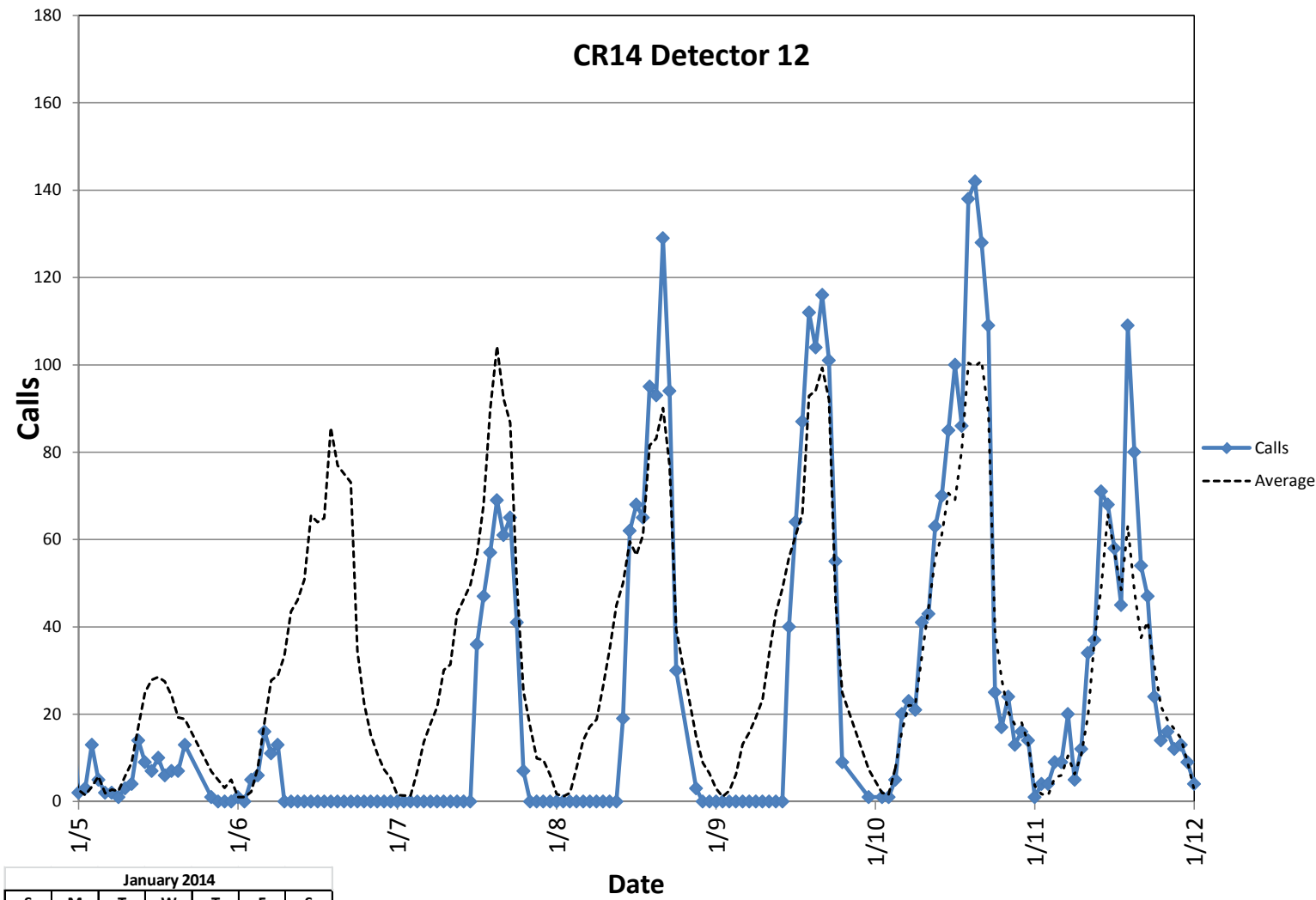
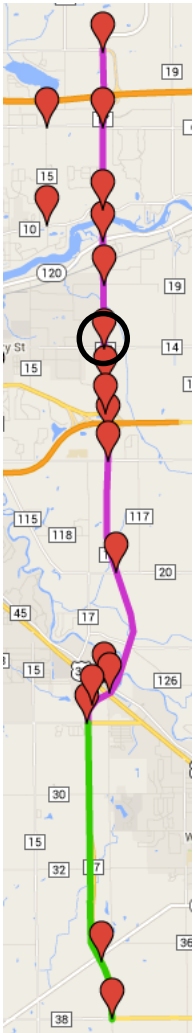


Standard Deviation ≥ 1.5
3 Consecutive Errors



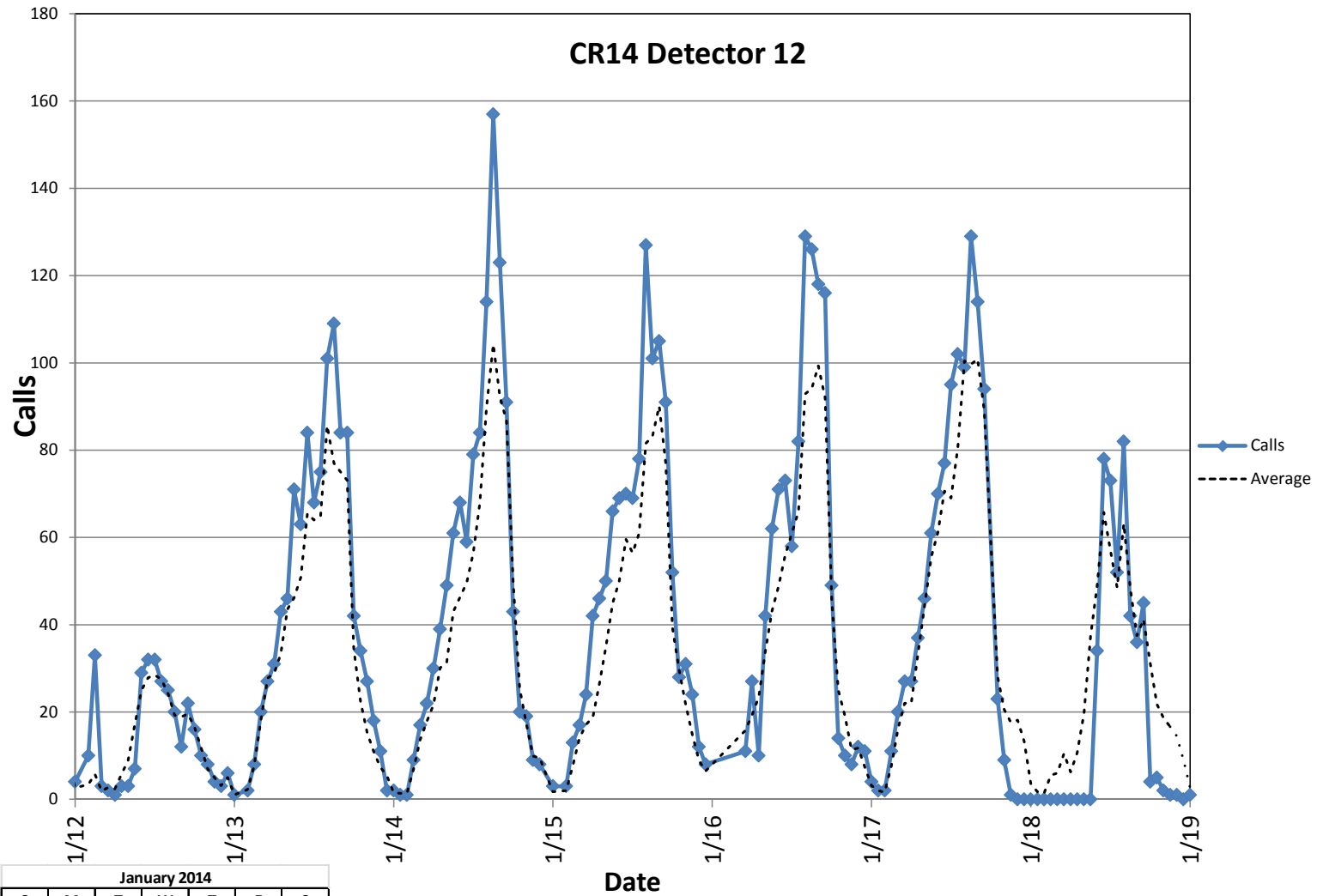
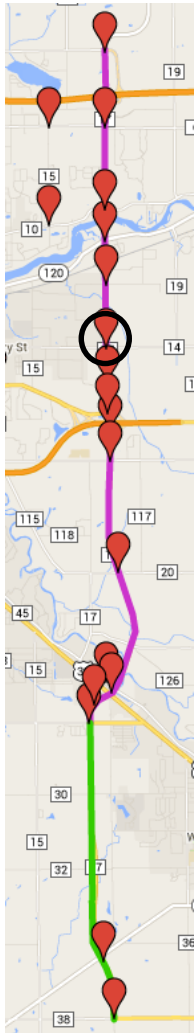
Standard deviation threshold better as a user definable value due to range of normal calls for various detectors within system. 1.5—2.0 is generally a good range.

Case Study: CR 14 January error event

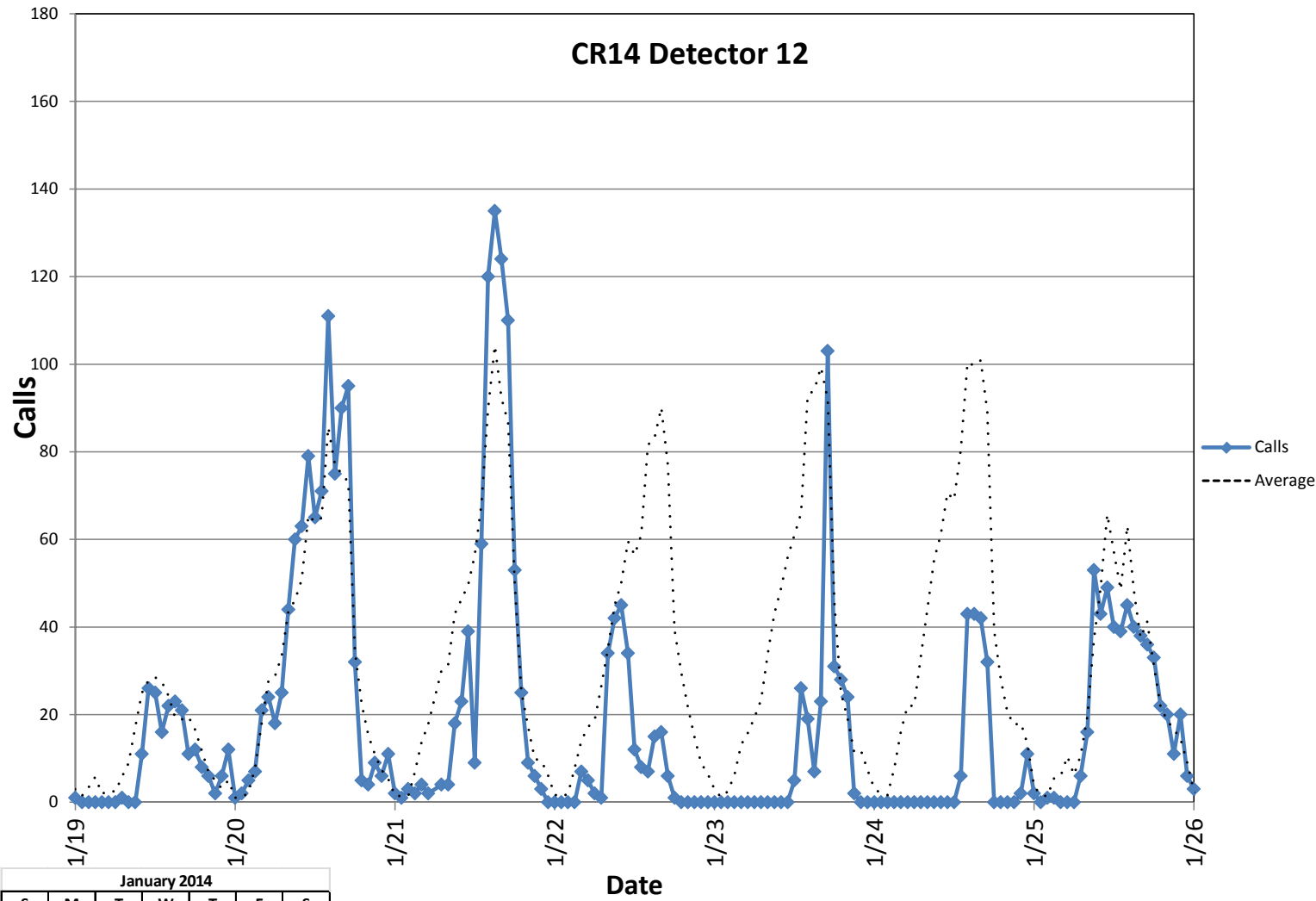
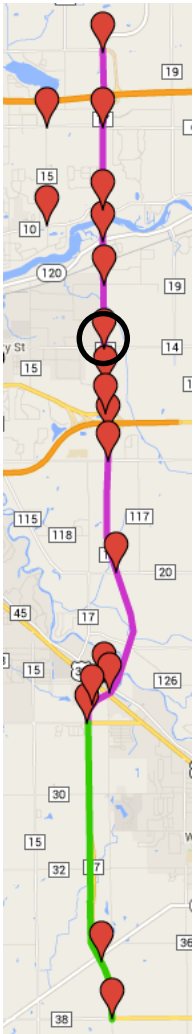


January 2014						
S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
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Case Study: CR 14 January error event

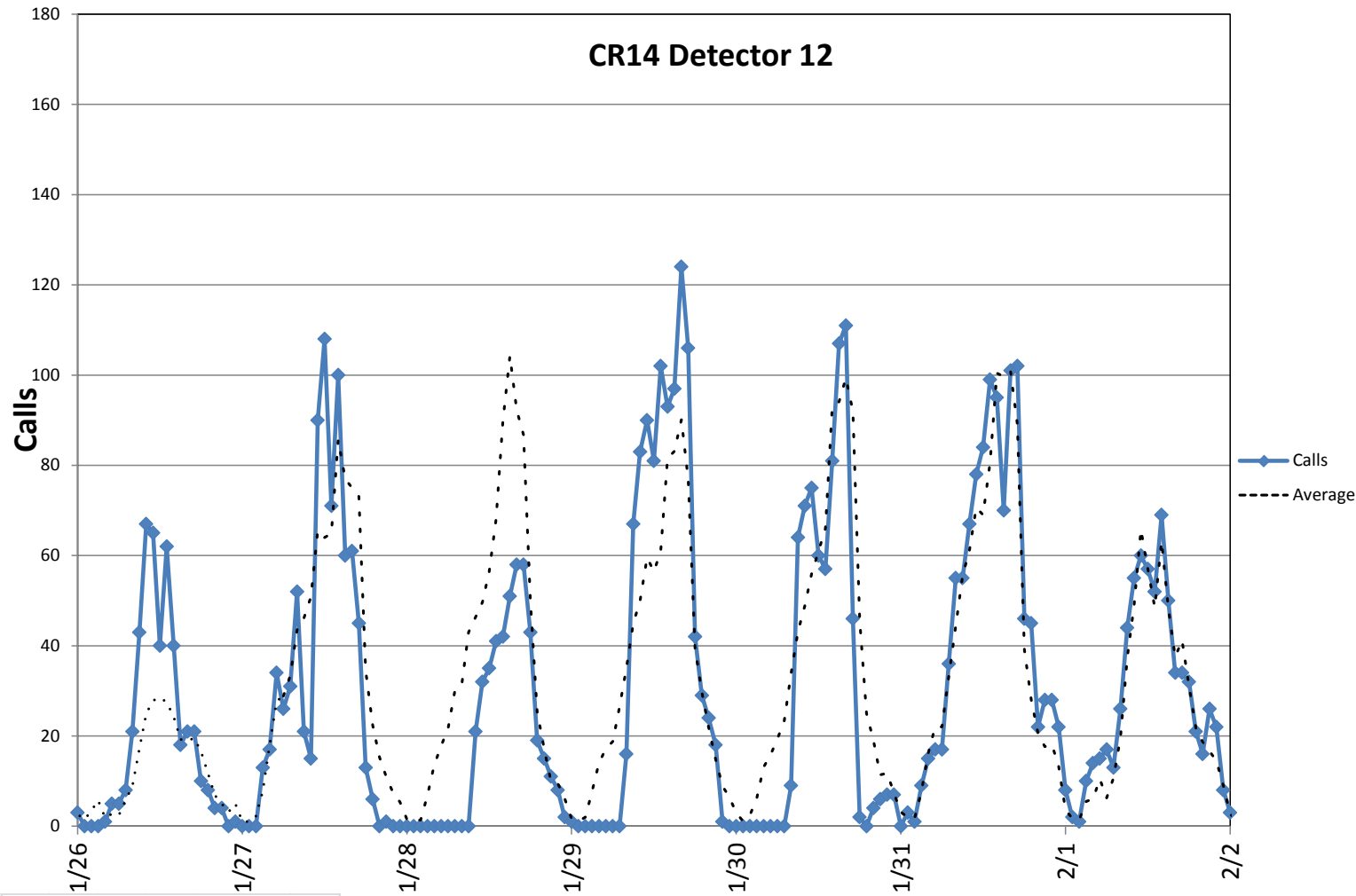
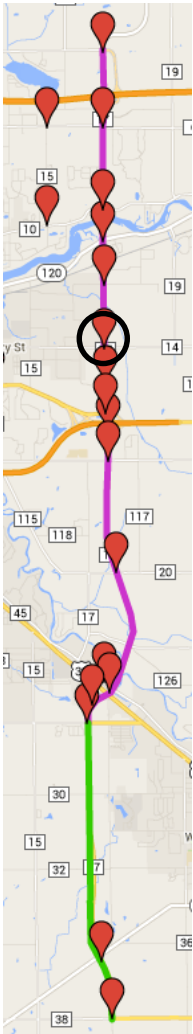


Case Study: CR 14 January error event



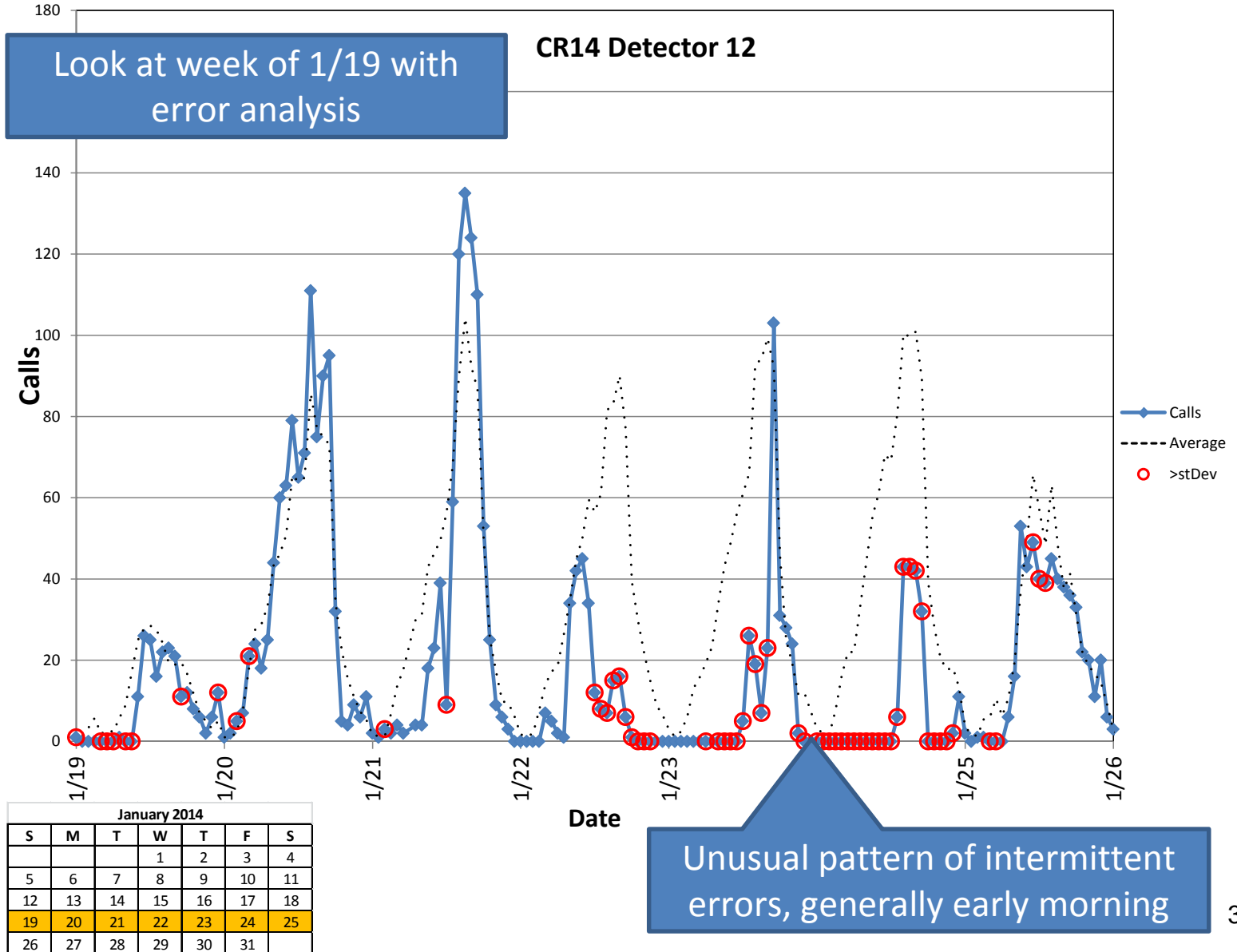
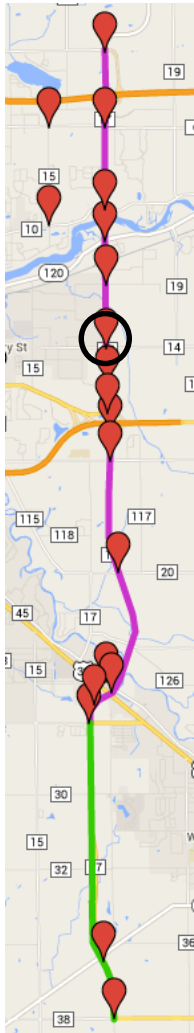
January 2014						
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Case Study: CR 14 January error event

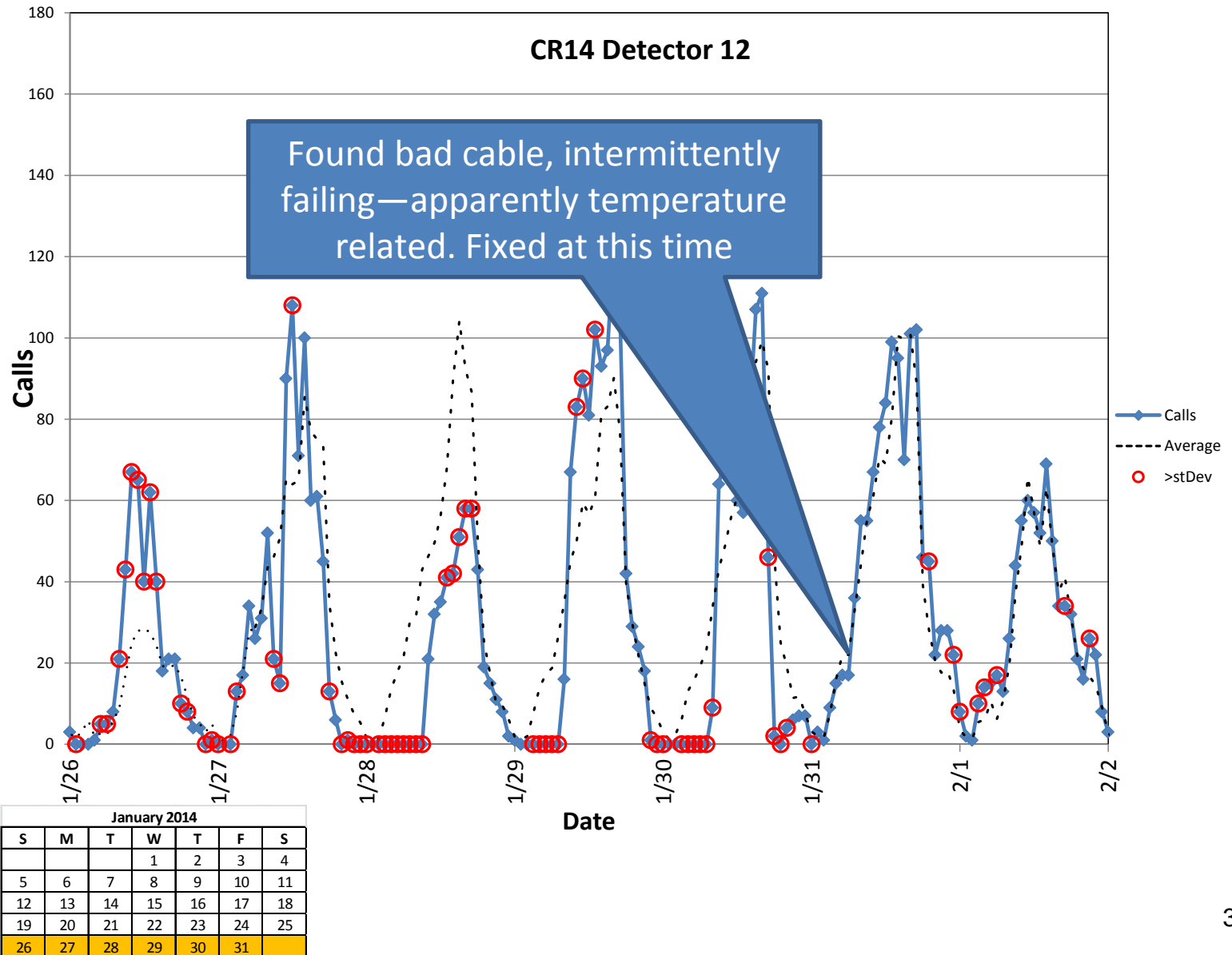
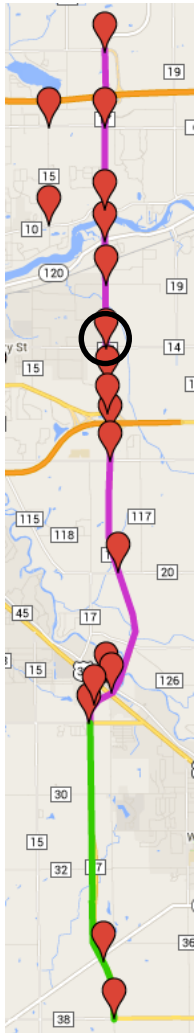


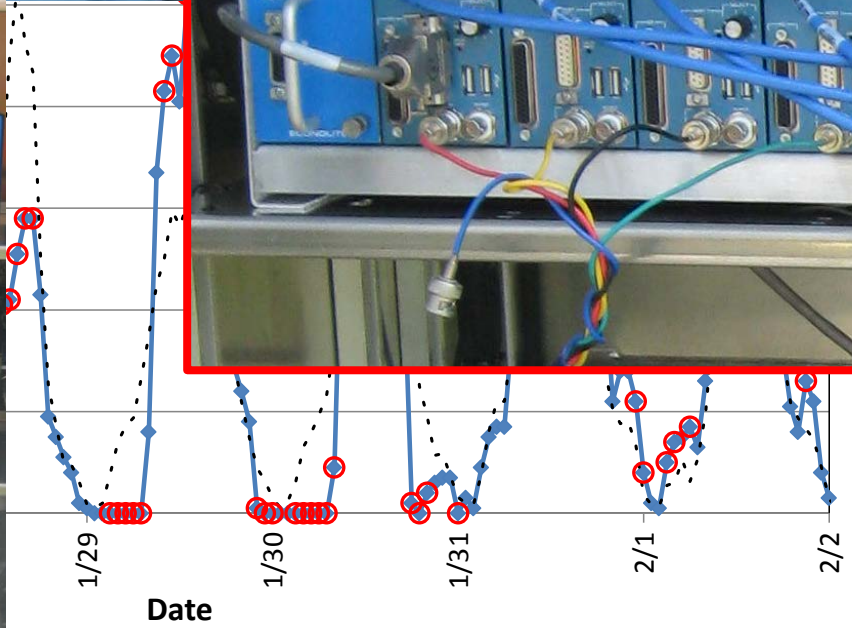
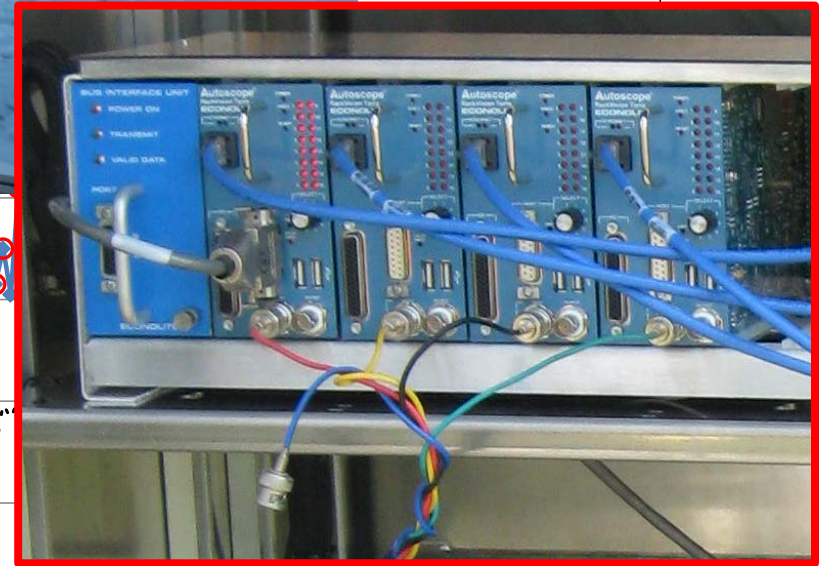
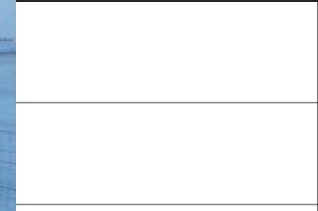
January 2014						
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			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
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Case Study: CR 14 January error event



Case Study: CR 14 January error event





Case Study: March 12, 2014 Snow Event

Heavy, wet snow blowing from the North, covering lenses and signal indications

Time (EDT)	Temp.	Dew Poin	Visibility	Wind Dir	Wind Spe	Precip	Events	Conditions
12:53 AM	37.9 °F	35.1 °F	8.0 mi	NNE	10.4 mph	0.00 in	Rain	Light Rain
1:53 AM	37.9 °F	35.1 °F	10.0 mi	NNE	10.4 mph	0.01 in	Rain	Light Rain
2:53 AM	37.9 °F	35.1 °F	10.0 mi	NE	13.8 mph	0.00 in		Overcast
3:53 AM	36.0 °F	33.1 °F	10.0 mi	NE	20.7 mph	N/A		Overcast
4:53 AM	34.0 °F	32.0 °F	0.8 mi	North	-	0.06 in	Snow	Light Snow
5:53 AM	33.1 °F	32.0 °F	0.2 mi	North	-	0.08 in	Fog , Snow	Heavy Snow
6:53 AM	32.0 °F	28.9 °F	0.5 mi	North	-	0.03 in	Fog	Fog
7:53 AM	30.9 °F	28.0 °F	0.5 mi	North	-	0.02 in	Fog , Snow	Snow
8:53 AM	28.9 °F	27.0 °F	0.5 mi	North	-	0.01 in	Fog , Snow	Snow
9:53 AM	28.9 °F	26.1 °F	0.8 mi	North	-	0.00 in	Snow	Light Snow
10:53 AM	28.9 °F	26.1 °F	0.8 mi	North	-	0.00 in		Overcast
	°F		1.2 mi	North	-	N/A		Overcast
	°F		4.0 mi	North	-	N/A		Haze
	°F		10.0 mi	North	-	0.00 in	Snow	Light Snow
	°F		10.0 mi	North	-	0.00 in		Clear
	°F		10.0 mi	North	-	N/A		Mostly Cloudy
	°F		9.0 mi	North	-	N/A		Overcast
	°F		10.0 mi	North	-	N/A		Overcast
	°F		10.0 mi	North	-	N/A		Partly Cloudy
	°F		10.0 mi	North	-	N/A		Clear
	°F		10.0 mi	North	-	N/A		Clear
	°F		10.0 mi	North	-	N/A		Clear
	°F		10.0 mi	North	-	N/A		Clear
	°F		10.0 mi	North	-	N/A		Clear
	°F		10.0 mi	North	-	N/A		Clear



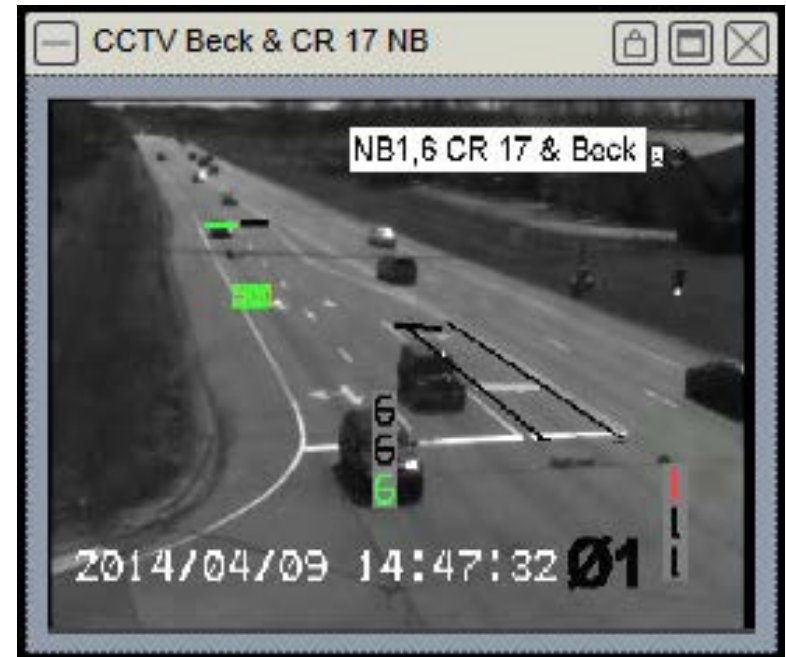
Photo: Elkhart Truth

Case Study: March 12, 2014 Snow Event

Beck Intersection Video Detection



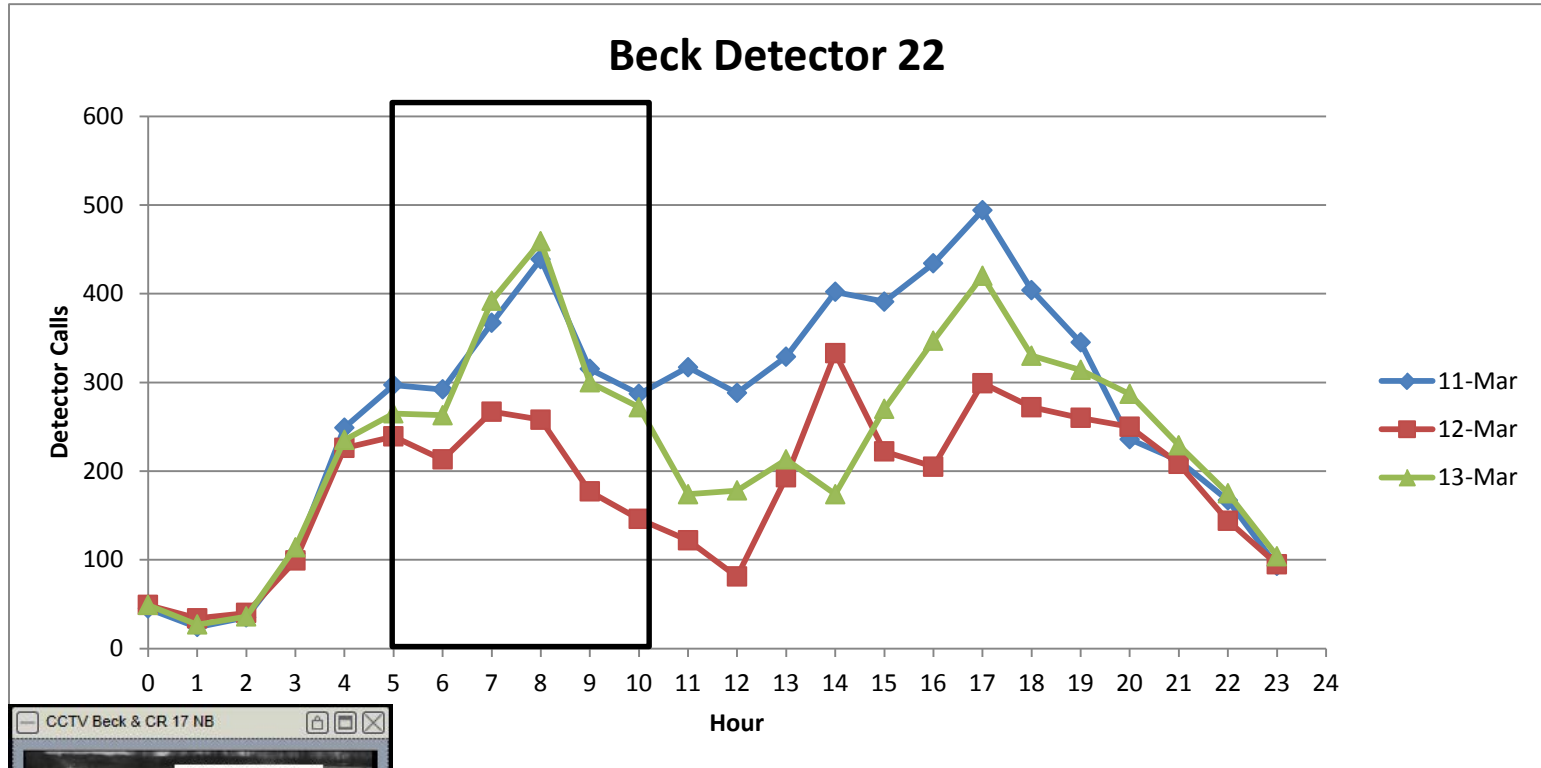
SB Detector 18



NB Detector 22

Case Study: March 12, 2014 Snow Event

Beck Intersection Video Detection

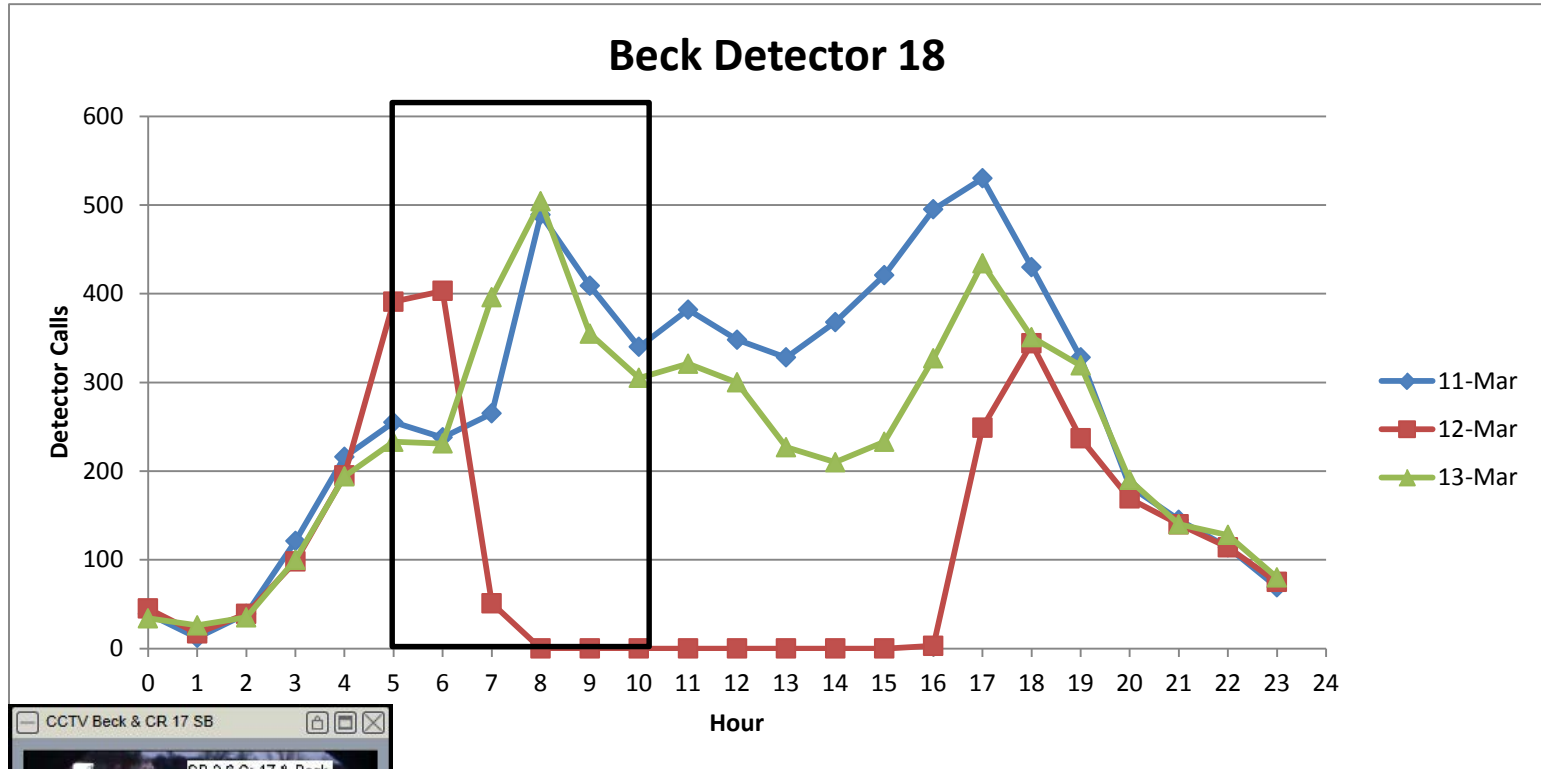


Facing South

NB Detector 22

Case Study: March 12, 2014 Snow Event

Beck Intersection Video Detection

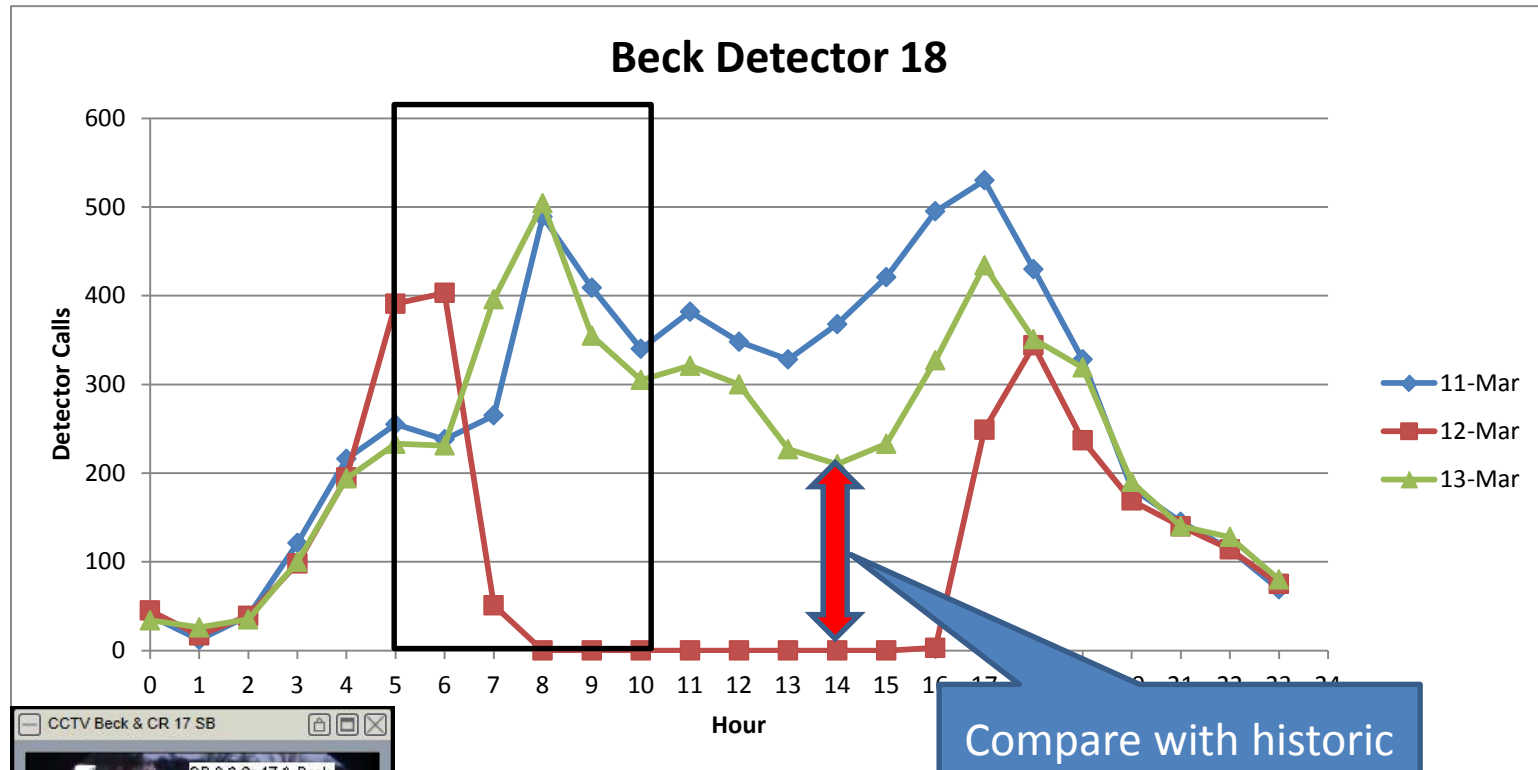


Facing North

SB Detector 18

Case Study: March 12, 2014 Snow Event

Beck Intersection Video Detection



Facing North

Compare with historic
'Normal' values to
trigger system alerts

SB Detector 18

Signal Detector Events

Configurable Report Options

Start Date & Time: 3/11/2014 2:15:21 PM

End Date & Time: 3/13/2014 3:15:21 PM

Signal Name: Beck @ CR17 (08NL Beck @

Signal Detector Events: BIU Faults, BIU Faults Clear,

View Report

1 of 1

Find | Next

Signal Detector Events

Signal(s):

Beck @ CR17 (08NL Beck @ County Road 17)

Time Range:

3/11/2014 2:15:21 PM - 3/13/2014 3:15:21 PM

Date/Time	Signal Name	Detector ID	Detector Name	Type	Phase	Phase Direction	Event
<div> <div>CENTRACS™</div> <div>1 of 1</div> <div>4/9/2014 3:15:55 PM</div> </div>							

System Events

Configurable Report Options

Start Date & Time: 3/11/2014 2:18:38 PM

End Date & Time: 3/13/2014 3:18:38 PM

Entity Type(s): Centracs, Data Collection St;

Entity Name(s): Beck @ CR17 (08NL Beck @

Events: Detector Communication Fa

Row Limit: 1000

View Report

1 of 1

Find | Next

System Events

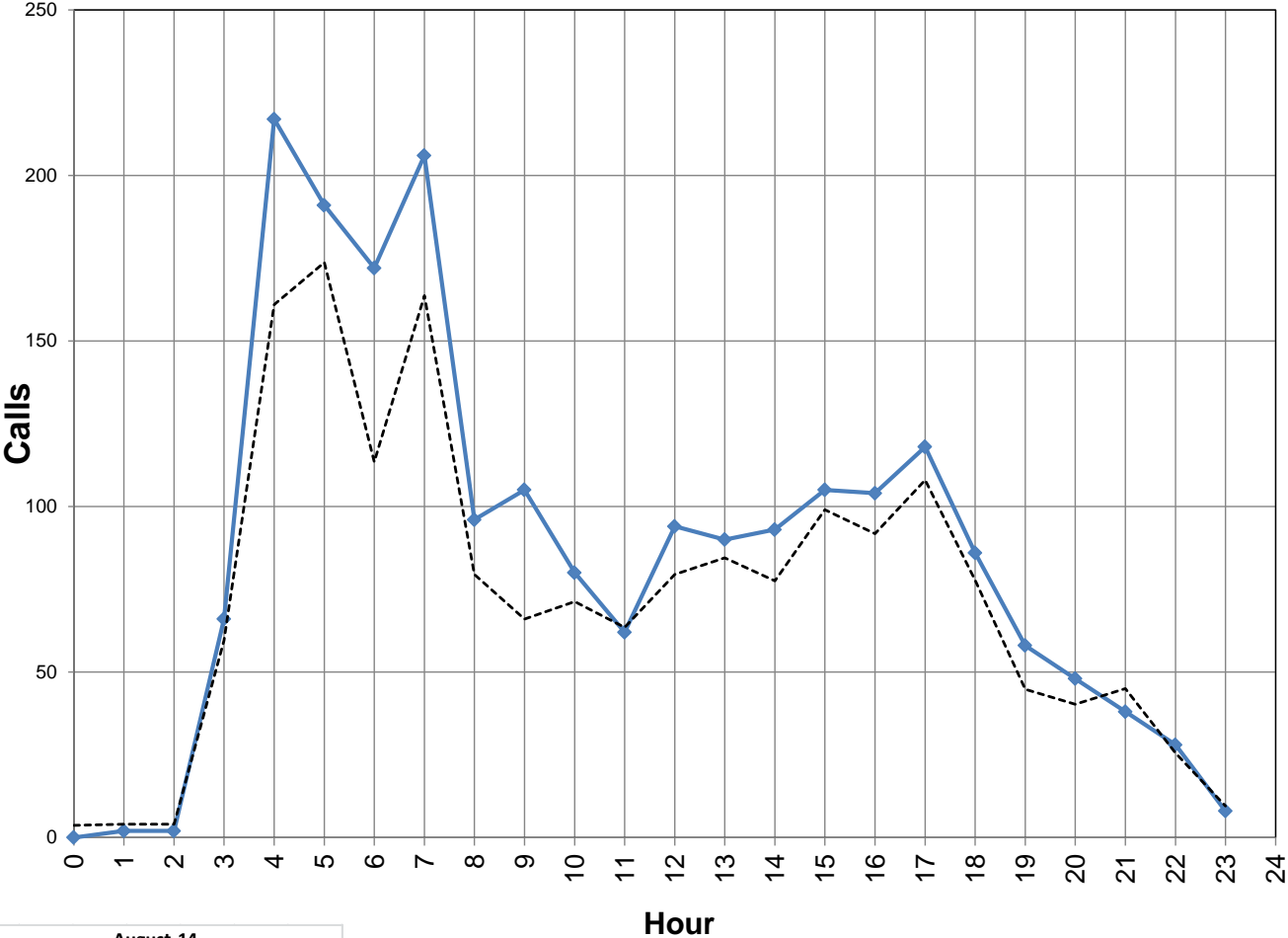
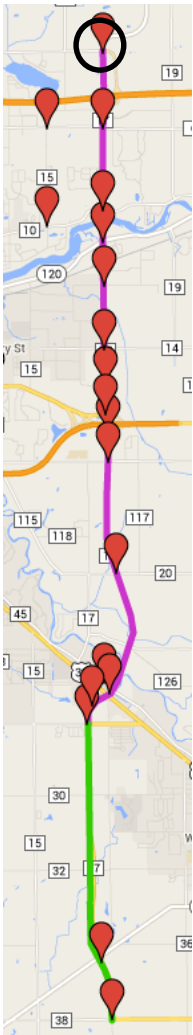
Time Range:

3/11/2014 2:18:38 PM - 3/13/2014 3:18:38 PM

Date/Time	Entity Type	Entity	Event Name	Details
<div> <div>CENTRACS™</div> <div>1 of 1</div> <div>4/9/2014 3:22:29 PM</div> </div>				

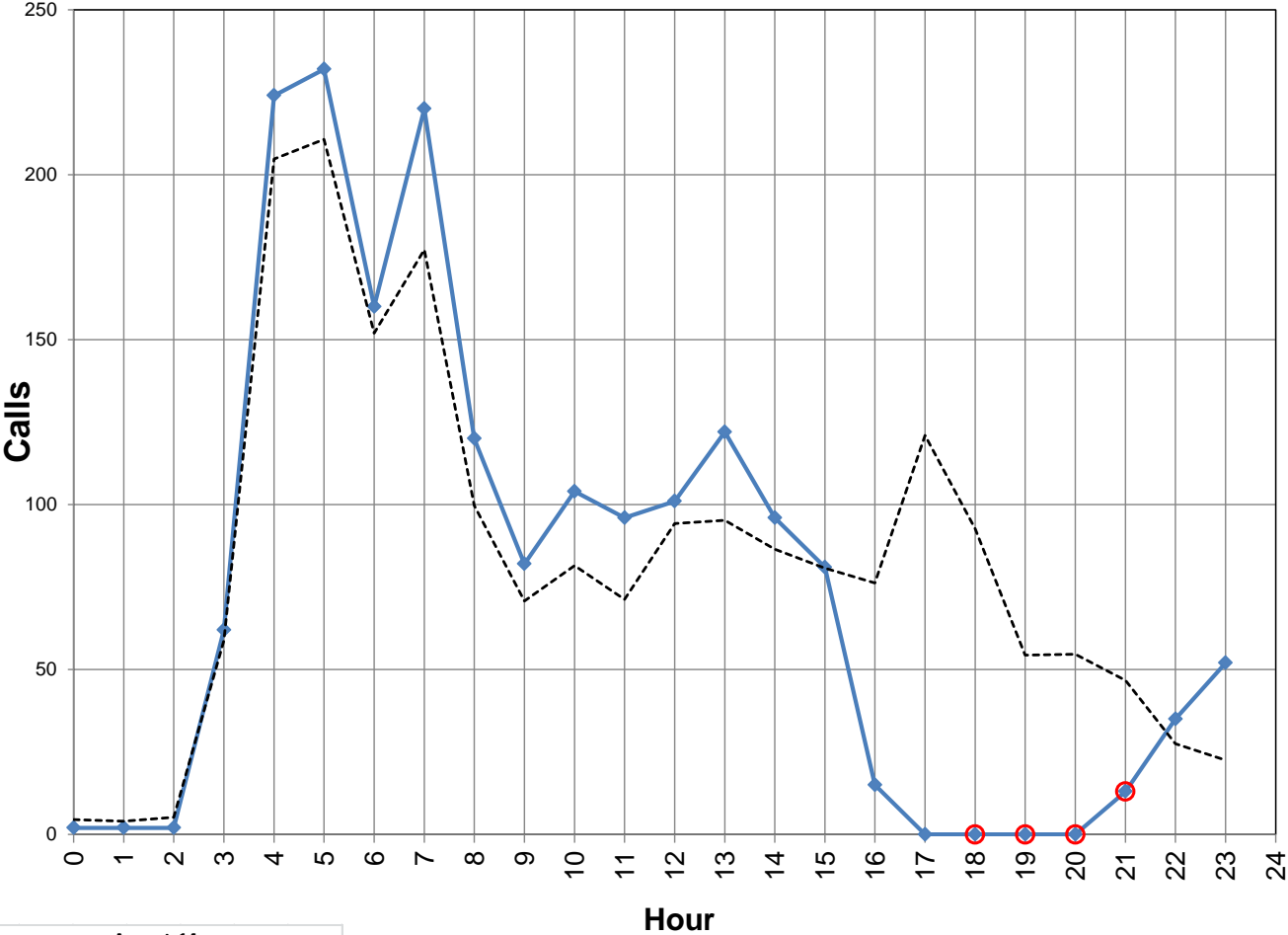
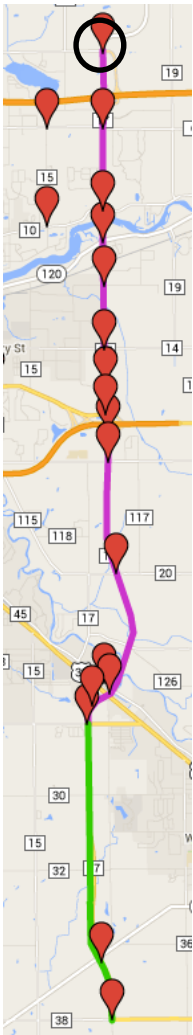
System Didn't
Report Any
Detection Errors

Case Study: CR 4 Loop failure



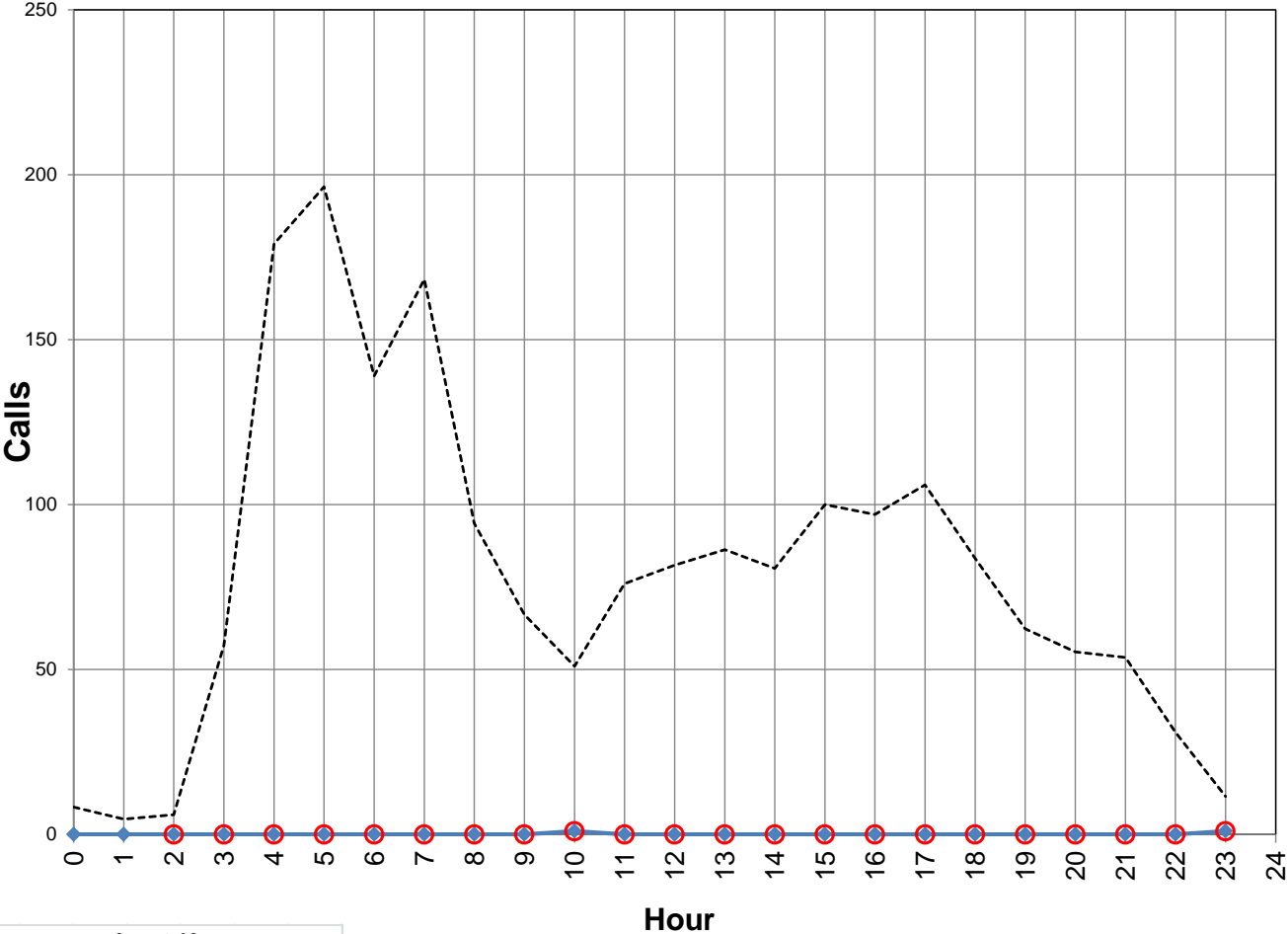
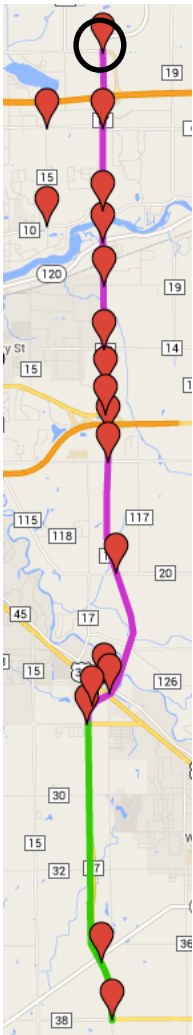
August-14						
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

Case Study: CR 4 Loop failure



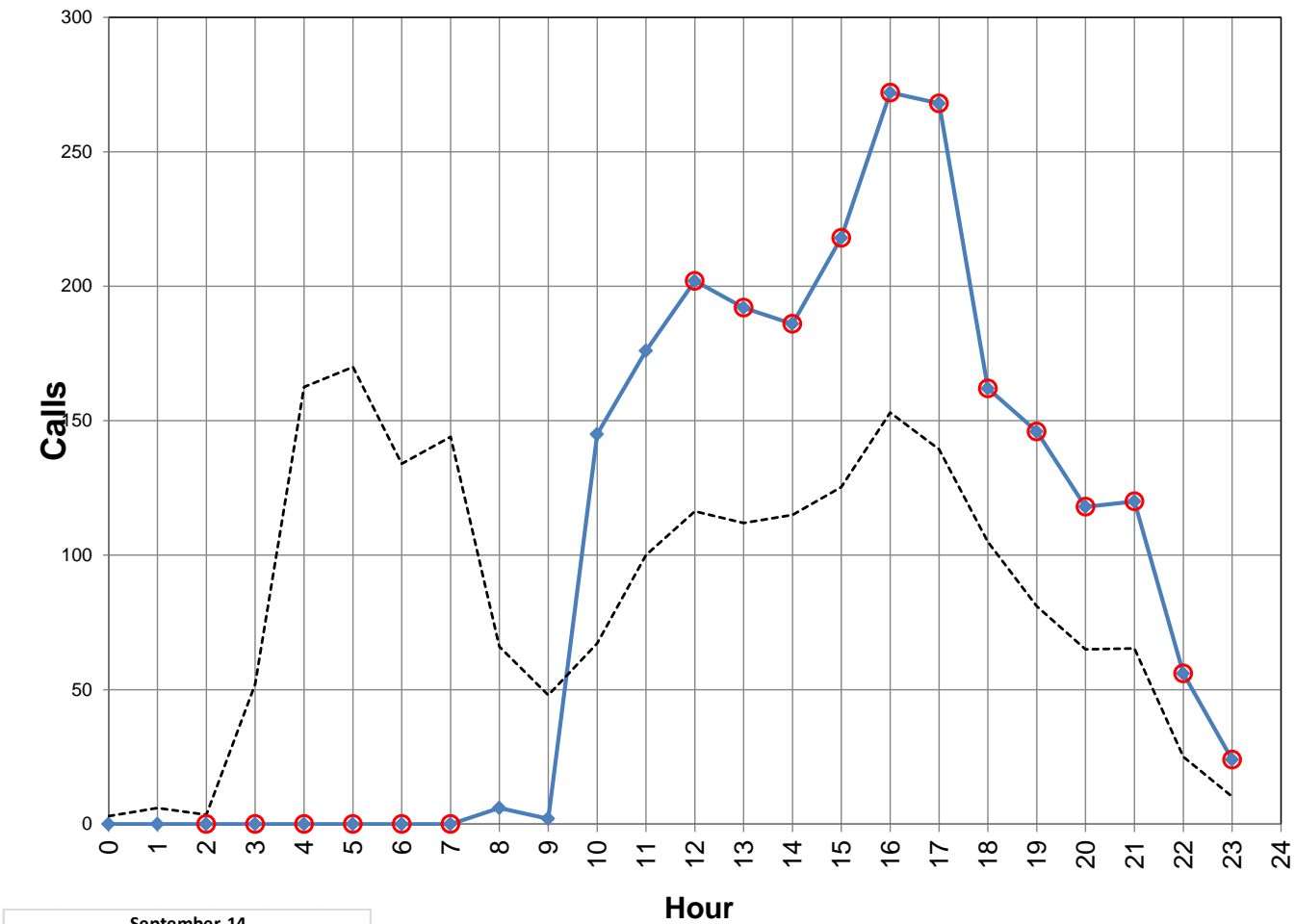
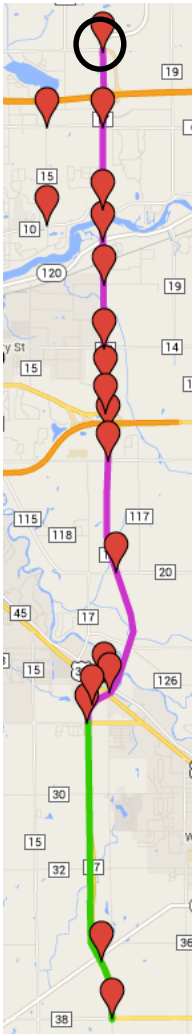
August-14						
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

Case Study: CR 4 Loop failure



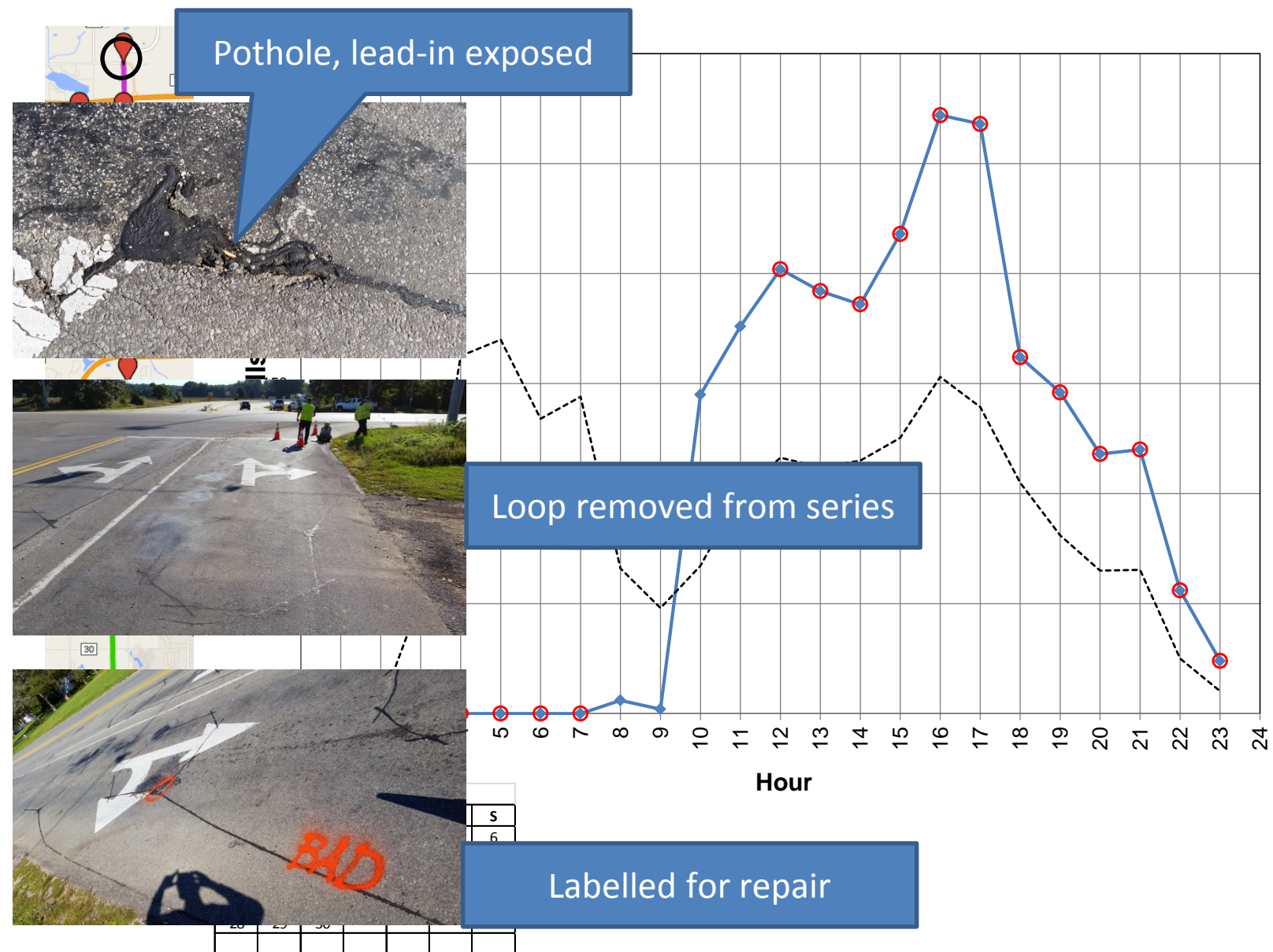
August-14						
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

Case Study: CR 4 Loop failure

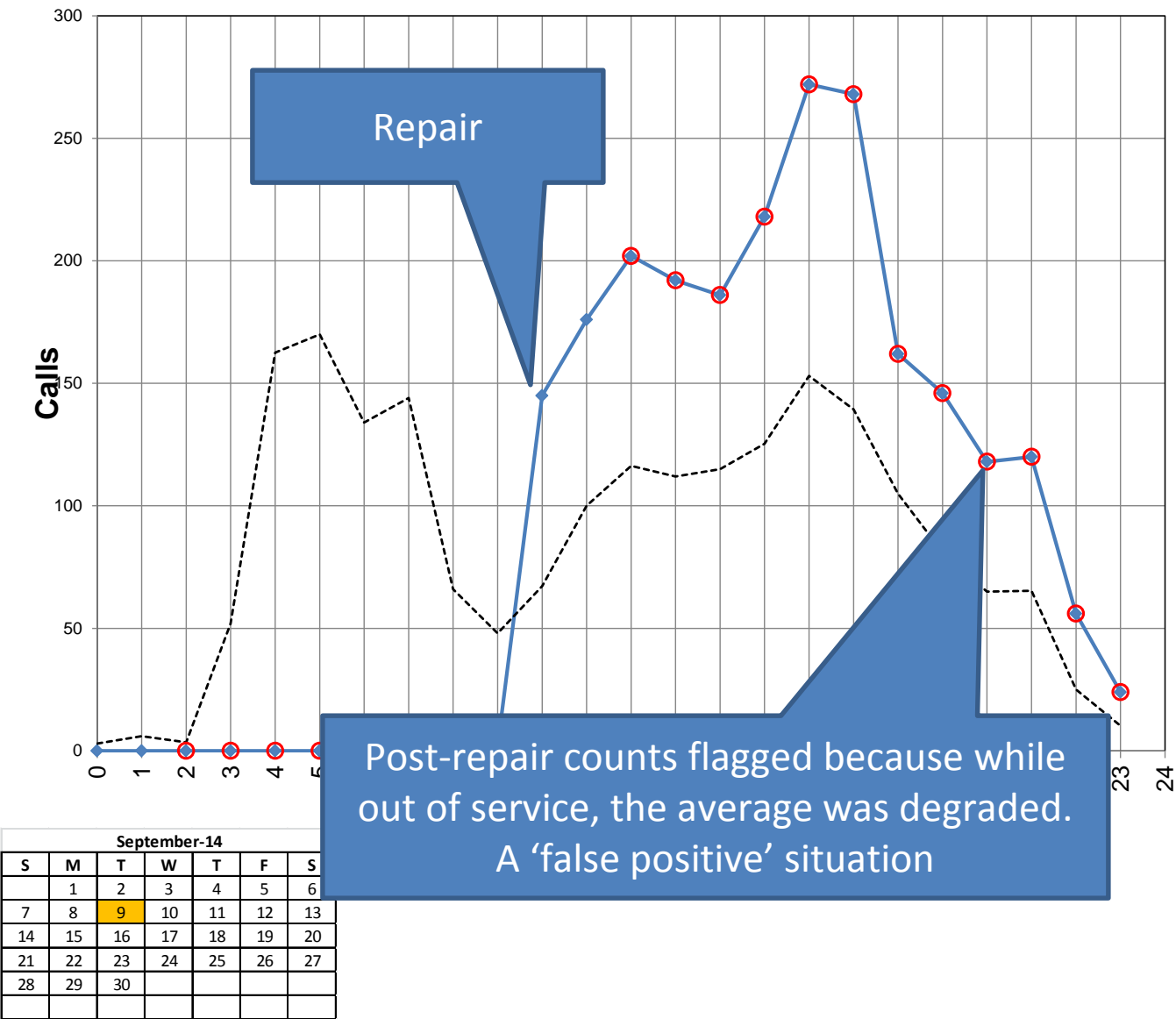
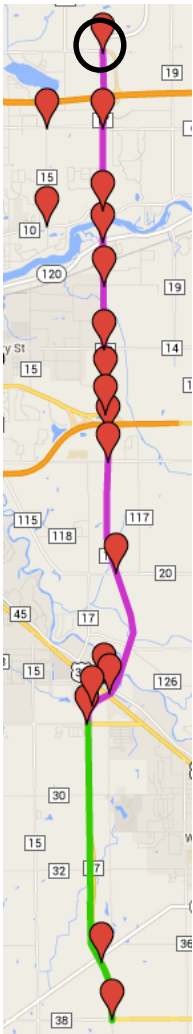


September-14						
S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

Case Study: CR 4 Loop failure

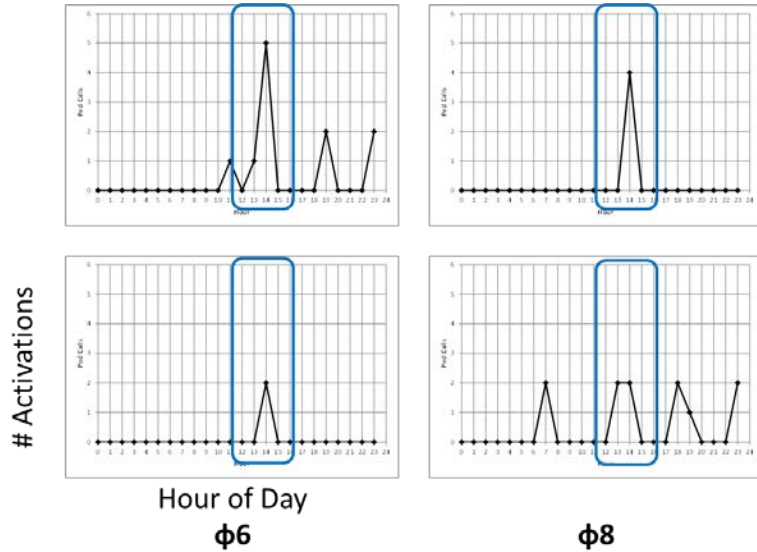


Case Study: CR 4 Loop failure

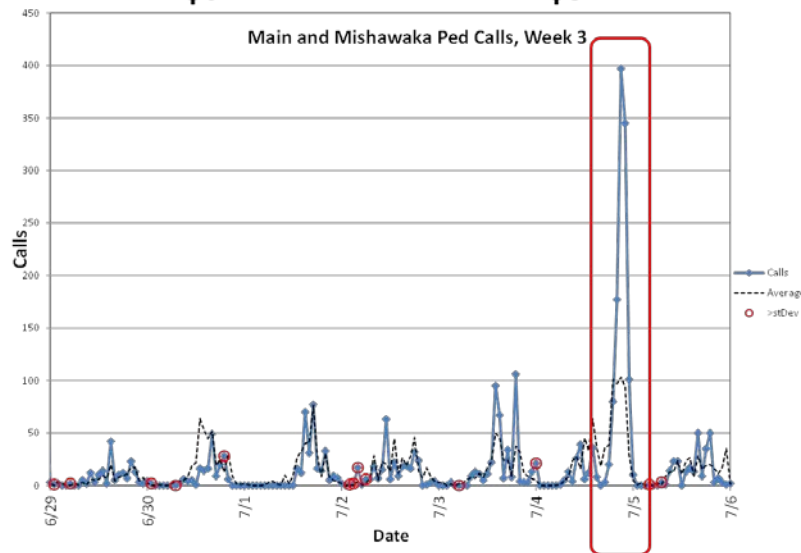


Conclusions

Maintenance performance measures

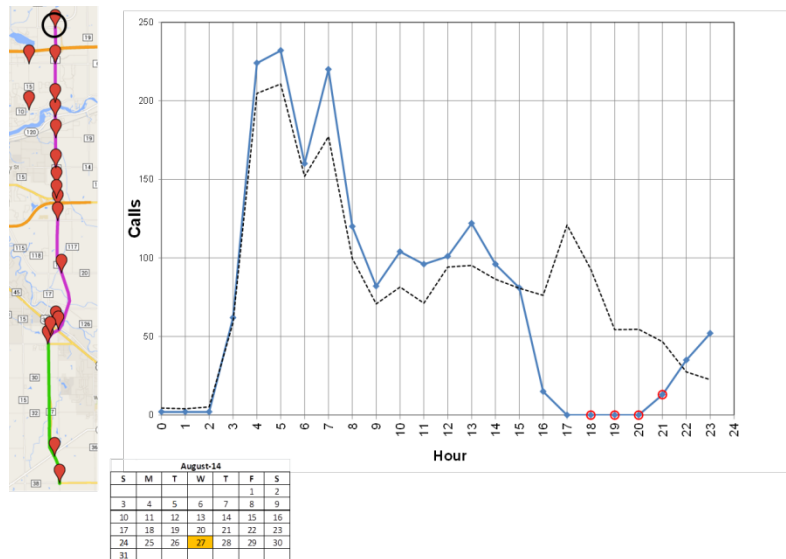
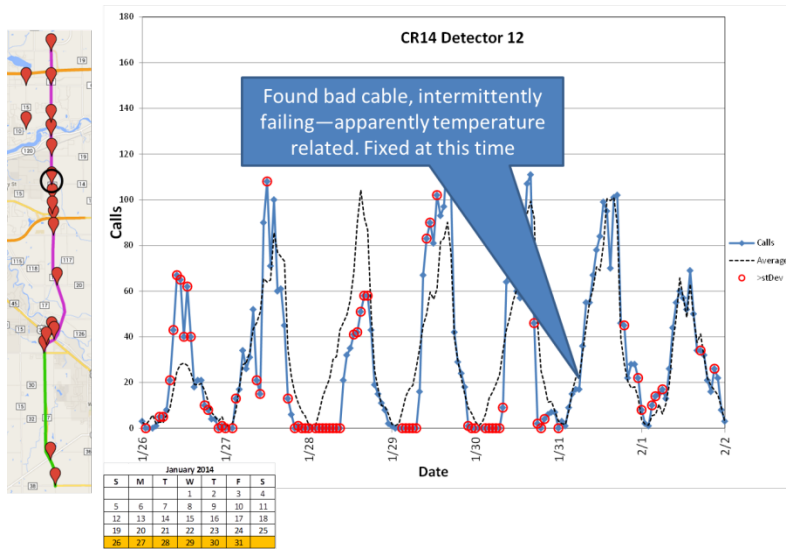


can be used to verify
operation of call buttons



can be used to identify
potential call button
errors

Conclusions



Maintenance performance measures

can be used to identify intermittent errors that equipment failure reports may not

can be used to identify traditional failures

Three weeks of data for base line creation and a standard deviation of 1.5—2.0 worked well in study for error determination

Conclusions

Performance measures allow local agencies to more effectively manage signal systems with limited staffing

Find errors before this:

Elkhart

TRAFFIC

Signal causes problem at C.R. 10 intersection

Traveling west of C.R. 17 on C.R. 10 there is traffic control at C.R. 15. In addition to the traffic lights, there are two cameras and sensors in the pavement. Often traffic on C.R. 10 is stopped due to a red light and looking to the north and south there is no vehicle in sight. Apparently the traffic control at the intersection is programmed to cycle the lights on an interval regardless of activation by any of the sensors or cameras.

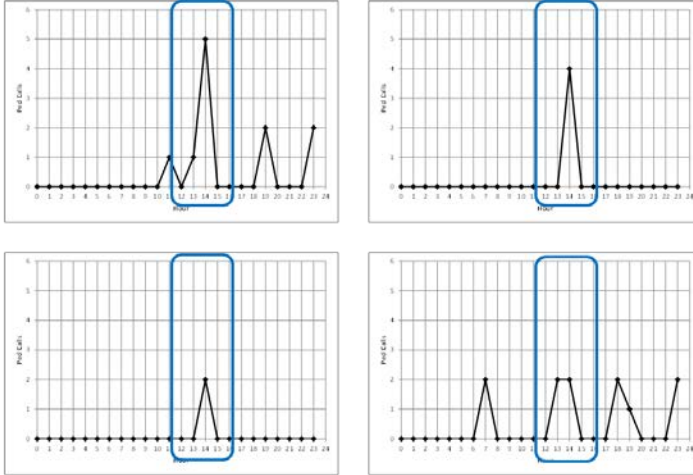
With the majority of the traffic traveling C.R. 10, why stop that traffic when there are no vehicles on C.R. 15 waiting to enter the intersection? It is a waste of time and gasoline to stop at a red light on C.R. 10 without any observed traffic on C.R. 15. While stopped on C.R. 10 one can observe the light is green for any traffic from the north while the traffic light is red for any opposing traffic.

If traffic lights (at any given intersection) are to be programmed to cycle on a set interval, why have the added investment of pavement sensors, cameras and additional cost required for the traffic control equipment? I suggest utilizing the installed sensors, cameras and equipment to safely and efficiently control the traffic flow to their intended capacity throughout the city and county.

Another traffic situation: A solid white line is not to be crossed by traffic. Southbound traffic on C.R. 17 has a very narrow area to legally enter the left turn lane to turn onto S.R. 120.

S.M. BOYER
Bristol

Activations



Hour of Day
 $\phi 6$

This work was sponsored by:

Indiana LTAP

and the

Joint Transportation Research Program at Purdue University

